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COLLEGE OF AERONAUTICS
(Proposed Cranfield Institute of Technology)
DEPARTMENT OF PRODUCTION ENGINEERING

DESIGN PROJECT 1968/9

REPORT OF ASSEMBLY PROCESS COMMITTEE

THE DESIGN OF A VERSATILE AUTOMATIC
ASSEMBLY MACHINE

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AUTOMATIC ASSEMBLY DESIGN PROJECT 1968/9

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SUMMARY

This report describes the approach to the design of an automatic versatile assembly machine of modular construction. Details of the design of the conveyor module, the platen upon which the assembly is mounted and the platen motivation mechanisms are included. It also includes the assembly system that has been applied to the assembly of an electrical contact block. This entailed a machine layout, the re-design of a component and the design and specification of appropriate fixing heads.

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1.0 Introduction

This report is one of a series which give full details of the design project 1968/9. A Management Report is available which summarises the work done and the conclusions reached during the course of the project (ref. 1).

The terms of reference of the Assembly Process Committee were to design and develop the basic structure of an automatic assembly machine, and to investigate the fixing heads that would be required for the assembly of electrical contact blocks.

In order to comply with the terms of reference of the project, one of the major considerations for the design of the machine was that it must be capable of assembling a variety of products. It is the opinion of the Committee that this has been achieved within the limits imposed by cost and practicability. The system that was decided upon possessed five distinct areas of investigation; these were:-

- a) an investigation into basic machine configurations.
- b) the design of the proposed system.
- c) the design of the platen and work-holding fixture.
- d) the design of the platen-lifting mechanism which is required at a work station. A mechanism for the rapid motivation of a platen was designed to be used as an accessory, should the cycle time of a workhead make it necessary.
- e) a general study of workheads and the specific design of those required to assemble the contact block. Quotations were obtained from suppliers.

One of the components of the switch was redesigned, and a recommendation was made to the Assembly Analysis Committee for the redesign to be adopted.

A cost break-down of the machine elements, which were designed by this Committee, is given in Appendix III in this report, together with a 2CL program for the manufacture of the platen and fixture(App.II).

2.0 Design of the Basic System

The Committee considered that the final system would possess the following characteristics:-

- a) versatility.
- b) the facility of adding or removing workheads with ease, so that the length of the system could be altered easily, as the product being assembled would require.

- c) the capacity for changing the sequence of workheads.
- d) economic viability.
- e) the work holder, if any, should be automatically returned to the starting station.

Before the basic types of assembly machines are discussed, it was considered necessary to discuss briefly the methods of transferring parts from one work station to another.

Parts that are to be worked upon must be held in a fixed position relative to the workhead; a high degree of accuracy is necessary for this position, so the assembly is normally held in a fixture. The fixture will generally be made as simple as possible for three reasons: low cost, speed of fitting component parts, and accessibility, the latter is most important when parts are being assembled automatically. The design of the fixture should be such that the components are adequately located with the minimum of fixing. In automatic assembly, there are two possible ways of moving the product from one position to another:

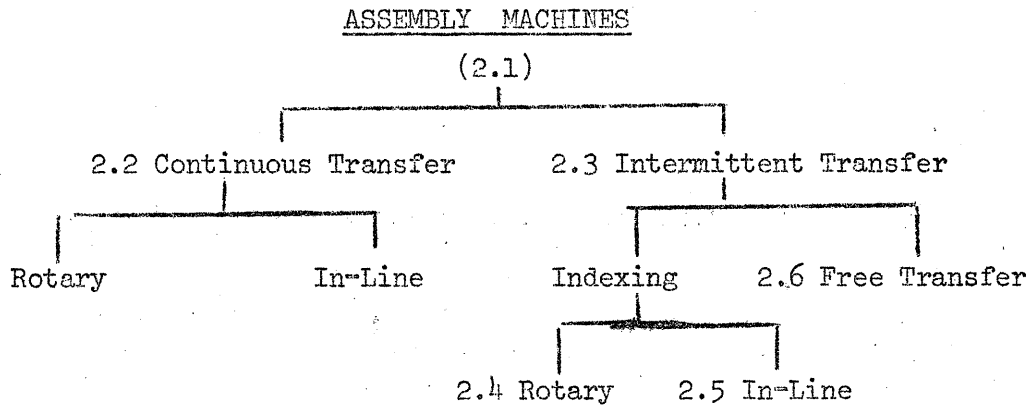
- a) the product and fixture are moved together.
- b) the product is removed from the fixture and is placed into another at the next position.

With the latter case, mechanical arms are required to accurately re-locate the component at the next workstation. The former possibility requires that the fixtures be accurately positioned at each workstation. As indicated in Boothroyd & Redford (ref. 2) of the two methods mentioned it is generally easier to locate a fixture accurately. Data quoted by Williamson (ref. 4) claimed location to 0.0001 in (0.0025 mm). Therefore, the investigation in the following section is based on the assumption that the product and fixture are moved together.

In the investigation that led to the final machine configuration, which is given in section 3.0, many systems were considered, a description of these follows.

2.1 Basic Types of Assembly Machines

The diagram indicates the type of assembly machines which are available and they can be classified into two main groups; these and each of the systems which derive from them are discussed separately.



2.2 Continuous Transfer

Continuous transfer means that the work carriers or fixtures move at a constant velocity, while the work heads are indexed backwards and forwards. It is apparent that the assembly operations cannot take place during the acceleration and deceleration of the workheads, so they operate only when they are adjacent to the continuously moving assembly, and when they have reached the same velocity. Normally, work heads are heavy machine elements, thus for them to be designed to reciprocate is a costly and generally undesirable feature. Therefore emphasis has to be placed on stiffness in the design, which is difficult to achieve with indexing work heads. The moving conveyor must have adequate rigidity because the assembly operations are carried out on it.

2.3 Intermittent Transfer

Intermittent transfer is more commonly employed than continuous transfer in assembly machines, and is used in both in-line and rotary systems. This method means that the work heads are stationary and the components are indexed past them. Assemblies are transferred simultaneously and are brought to a halt to enable the assembly operations to be performed. Systems in this category are termed indexing machines. Because the workheads are fixed, their design is simplified, and hence these systems are cheaper to build than continuously moving ones. Moreover, it can be appreciated that parts-feeding is less complicated than in continuous transfer systems, because the feeding units remain stationary. Feeders and parts-flighting equipment are classed as tooling and when versatility is a major consideration, these items are required to be changed periodically and therefore must be made as cheaply and as simply as practicable.

The major difficulty of this form of transfer is the exact positioning of the work holding fixtures, and there are problems involved in increasing or decreasing the length of the system.

2.4 Rotary Indexing Machines

This system has the desirable feature that the work holders or fixtures are returned to the starting point, ie. the position immediately following the last operation. The maximum number of operating positions that can be arranged around the perimeter of the table is limited. One method of overcoming this is to have two or more adjacent rotary tables, and to transfer the assembly from one rotary table to another. There are many methods of indexing rotary tables, the most commonly used are:-

- a) Rack and pinion with unidirectional clutch.
- b) Rack and pinion with ratchet and pawl.
- c) Ratchet and pawl.
- d) Geneva mechanism.
- e) Cross over indexing cam.

These techniques are explained in detail by Boothroyd and Redford (ref. 2).

2.5 In-Line Indexing Machine

This system enables the assemblies to be built in a straight line, thus simplifying the problem of increasing the number of workheads. This is normally done by increasing the length of the conveyor mechanism by one or more modules. Using this method the assembly is removed from the conveyor after the final operation, and therefore it necessitates the fixtures being returned to the beginning of the assembly line. This can be performed by using another conveyor to return the fixture. A problem with this type of system is that "stretch" of the conveyor can occur. In systems of substantial length, changes in ambient temperature can cause significant errors in the assembly process; these errors can be minimised by introducing ambient temperature control, but this adds to the cost of the machine. If the assembly fixtures are attached to a steel band type of conveyor the return is automatic.

2.6 Free Transfer System

The assembly is stopped under the work head while the conveyor continues to move, and the assembly operation is carried out. On completion of the operation, the product is released and allowed to move on to the next work head, while the following assembly is restrained. This system allows for easy extension by adding a module and lengthening the conveyor (usually a belt conveyor). The work carrier can be returned to the starting point by one of three methods; manually, by using a second belt conveyor, or by using the

return strand. The latter method needs a lifting mechanism to return the fixtures to the upper level. When the products are assembled on the belt, problems occur due to undulations of the conveyor. If one assembly operation is considerably longer than the others in the process, this operation can be "doubled" by mounting one process head on each side of the conveyor and using a simple gate to facilitate feeding the products to each head. This has the desirable feature of reducing the cycle time and thus increasing output. It should be remembered that the cycle time will be the longest operating time, plus the time taken to travel between operating heads. A major advantage of this system is that if a process head breaks down, a manual operator can maintain production while the process head is repaired.

Fig. AP1 lists the advantages and disadvantages of the systems discussed.

The addition of an in-process float can be of great benefit when it is included in a free-transfer and indexing system. It has the effect of reducing the time taken to travel between workheads, particularly when the distance between process heads is great. Substantial distances are often required by layout considerations, and the need for access to workheads and feeders.

3.0 The proposed System

The proposed system (see fig. AP2) that meets the requirement of versatility is described below, and is aimed to include the advantages of the systems previously discussed in section 2.2 to 2.6.

The conveyor that was chosen is of the slat and link type (see fig. AP8); the slats are shaped to enable the conveyor to be turned through 360 degrees at a minimum radius of 5.25 in (134 mm). Therefore, this enables the work carrier to be returned to the first work station of the machine (see fig. AP2).

The conveyor is designed in unit lengths to enable the system to be lengthened or shortened by the addition or removal of units. This means that the number of work heads in the system can be varied as required. The work heads are such that they can be added to the assembly line easily. Slight variations in height can be achieved by the adjustment in each leg of the workhead stands (fig. 9).

The working height of the assembly has been ergonomically designed.

The work heads are adequately spaced to enable manual operators to be used in the assembly line, when a work head or pick and place unit needs repair. The operator can also be used when a difficult or cost prohibitive operation is to be undertaken.

The assemblies are mounted on a fixture which is unique to each product being assembled. This fixture is then mounted on a platen or pallet. Thus, the platen is common to the system and is suitable for assembling any product of size up to 4 in (100 mm) cube.

As previously stated, the work heads are placed well apart and this allows an in process "buffer-stock" to be situated between each work station. This reduces the time that the work station is waiting for the next assembly to enter the working position. If it is required to reduce this waiting time further, a mechanism has been developed by the Committee (fig. AP16), to pull the assembly rapidly from the "buffer stock" to the working position.

The platen, because it is resting on the slats, undulates slightly. This is an undesirable feature which has been overcome by a lifting mechanism that lifts the platen off the conveyor while "buffer stops" prevent the following platen from moving into the work head. The platen is raised on three hemispheres which locate in "vee" shaped recesses. These vees are machined on the under-side of the platen and are positioned to provide kinematic location. Upon completion of the assembly cycle, a signal is received from the control system, and the platen is replaced on to the conveyor. It is then released and allowed to move out of the work station.

This system also allows "doubling up" of slow operations, where necessary, by allowing two platens to pass through the buffer stock into two adjacent work heads. It should be realised that this system does not operate on the principle of indexing and therefore the operation time is not necessarily dependent on the slowest operation if the "doubling up" facility is used.

The process heads and the pick-and-place heads have been arranged to be mounted on a common work stand. Each assembly module has its own control which is monitored on a central control panel to inform maintenance staff where a break down has occurred.

The work heads have been arranged inside the system and the pick and place units and parts feeders arranged around the outside to allow line loaders to have easy access to feeder units.

The platen is arranged with an indicator arm which has two positions, one indicates that the assembly is a reject. The reject assembly is removed at the end of the assembly line. The reasons for not rejecting at every station are listed below:-

- a) It is necessary to collect the platens at reject points and return them to the starting point.

- b) Because of (a) there is a reduction in platens in the system, therefore probable reduction in efficiency.
- c) Expense in setting up reject gates at each work head and subsequent escapement tracks.
- d) Reject gates make repositioning of work heads difficult.

It was considered, therefore, that physically marking the platen for accept or reject assemblies was more desirable.

Machine Layout

The conveyor design can be arranged in a variety of configuration, ie. circular, square, rectangular and any combination of the above shapes. The layout may, therefore, be governed by local environmental conditions which occur in factories and even changes from one floor level to another can be accommodated without difficulty. This means that generally, buildings would not need altering or floors floated, prior to installing the assembly machine.

4.0 The Conveyor Module

The basic concept of the machine was determined by considering the factors outlined in Section 2.0. Section 3.0 described the principles of operation of the proposed machine, and from this there arose three basic designs, one of which was to be selected. These were as follows:-

- a) a monorail that encompasses the drive mechanism, and the platen rides on the conveyor its centreline coincident with that of the rail.
- b) two rails support the platen, one rail provides facilities for the drive mechanism, the other acts as a stabilizing rail for the platen.
- c) an aerostatic slide forms a monorail.

These designs are shown in fig. AP3.

System (a) was selected, the reasons for rejecting the others are given briefly below.

System (b) offered the facility of enabling assembly to take place on the underside of the component. For this to be achieved, section or sections must be removed from the platen. This results in a loss of strength and loss of versatility of the platen. Another major disadvantage of this is that it is undesirable to feed components vertically upwards because they become difficult to control.

System (c), the aerostatic slideway system, was rejected because its feasibility was considered suspect, for the following reasons.

- a) time required for development of the system.
- b) running costs would be higher than with other systems.
- c) cost of manufacturing the machine would be higher than for the other two systems.

The module design that was finally decided upon is described in the following paragraphs. The justification for adopting particular design features is included with the description of the system. Stressing details are given in Appendix I.

Each module is 6 ft. (1.83 m) long, and its overall height is 2.5 ft. (760 mm). The need is for a structure that is capable of meeting the requirement of versatility, therefore the emphasis is placed on simplicity of design. The slat and link type of conveyor requires drive and idler sprockets to be used, this necessitates that the module be modified as shown in figs. AP6 and AP7 and is described later. The elements comprising the module have been designed to be easily detachable to enable modifications to be carried out with ease. Example of the types of modifications are:-

- i) if a work station is to be added between two existing work stations, the Guard and Guide Rails will require the removal of a section to enable the lifting mechanism to be installed.
- ii) the Module can be shortened by detaching the Guide Rail Assembly and the Base and cutting them to the desired length. The Strut would then be bolted to the Base in the new position.
- iii) when a module is modified to carry a sprocket (see AP6, AP7), the strut has to be drilled and tapped in order to attach the appropriate bracket to it. The Guard and Guide rail assembly will require modification at their extremities. Appendix I includes stress calculations of the module.

4.1 The Base

This is a standard channel section onto which lugs are welded for bolting to the floor of the factory. A plate can be bolted in conjunction with the lugs on modules to act as a tie. If extra rigidity is required on the Conveyor, a Strut may be placed at any position along the Base by drilling six holes and tapping at the appropriate place.

4.2 The Bottom Plate

To distribute the load that is transmitted through the Strut, the Bottom Plate is welded to the Strut. Six holes are provided in this plate to take attachment bolts which secure it to the Base. As an alternative to fixing this plate by tapping the base, nuts and locking washers can be used. This requires that the base be unbolted from the floor to allow access to the under surface. This is obviously a more involved and time consuming process.

4.3 The Strut

To the top of the Strut is welded an attachment block, this is stepped in each side to provide location of the Guide Rails. The attachment block is drilled and tapped so that the Guide Rail assembly can be bolted to it.

4.4 Guide Rail Assembly

Two standard tee-section rails are interconnected by a plate which is welded to the flanges as shown on fig. AP4. Adequate clearance is available between the bottom of conveyor links and this plate so that any components that are small enough to fall between the slats into this area, will not foul the link drive. A slat can be easily removed, thus facilitating periodic clearing of this area of stray components.

Due to the nature of the bearing material that is bonded to the under surface of the slats, the upper surface of the Guide Rails is ground to better than 6.3×10^{-4} μ m C.L.A. finish on the inner flange of the tee-section.

4.5 Guard

This has a two-fold purpose, one being to provide a location for the platen, thus restricting its sideways movement, the other being for safety reasons. Sections are removed from the guard where the motivation and/or lifting mechanism is required.

4.6 Slat and Link

The assembly of this item is shown on fig. AP8. It is a standard product, the supplier and specification is given in Appendix III. A slat can be readily removed facilitating coarse adjustment of the conveyor tension.

Two strips of bronze-impregnated PTFE are bonded with araldite (epoxy resin) to each side of the slat under surface to provide low friction and to reduce noise. It is anticipated that this strip will be replaced annually.

4.7 Drive and Idler Wheel Arrangement

The motor and gear box detail can be obtained by referring to the Control and Motivation Committee Report (ref. 3). The idler wheel arrangement is shown on fig. AP7 and this gives the basic alterations required on the elements of the module. Figure AP6 gives the drive wheel arrangement and it shows that the modification required on the module is identical to that required for the idler wheel. The additional feature that is required is a stand for the motor.

4.8 Adjustment of Conveyor Tension

As mentioned before, the slats can be removed which means that the adjustment of conveyor length is obtainable in 2 in (50 mm) increments. Fine adjustment of tension is obtained by moving the single slat guide and idler wheel bracket as shown on fig. AP7. This is facilitated by elongated holes in these items.

5.0 The Platen

The platen design is as shown on fig. AP11. The platen will accept assemblies up to 4 in (100 mm) cube mounted on it. The surface of the platen has a matrix of holes drilled in it which have been counterbored on the underside to accept 2BA set screws. These enable fixtures or special purpose clamping mechanisms to be screwed to the platen, or where appropriate the base of component being assembled.

The platen has been designed in this manner for the following reasons:-

- a) to accept a variety of assemblies ie. versatile
- b) to be simple in design
- c) to be cheap to produce
- d) to be repeatable to a high order of accuracy
- e) to be repositioned to an accuracy of better than 0.001 in.

To meet the requirements as stated in (c), (d) and (e) the bottom face of the platen has 3 vee grooves machined into it; these are arranged at 120° to each other. The vee grooves locate in three hemispheres which are mounted on the jacking mechanism. Therefore, as the platen is raised from the conveyor, slight errors in its positioning are eliminated.

Mounted on the side of the platen is the accept/reject arm. The two positions of this arm are indicated on fig. AP11. This facility was added to the platen to meet a requirement of the Control and Motivation Committee (ref. 3); this was that the platen should be physically marked at any work head when an assembly operation is unsuccessful. The control system activates a pneumatic cylinder which moves the arm to the appropriate position, as shown in fig. AP13. At the final work head, the arm will be returned to the accept position (see fig. 14). It should be noted that the top surface of the platen and the vee slots are machined by grinding, to achieve the repeatability and accuracy required for location.

Versatility

The platen can be considered as versatile when it is considered that any shape of component, within the previously stated size, can be mounted on it. There are various types of mountings, three are listed below:-

- a) fixture (special purpose and therefore should be simple)
- b) clamping devices
- c) fitted plugs in the holes in the platen.

The Fixture

The fixture has been designed for the assembly of the electrical contact block. This is a special purpose item, and is shown in fig. AP12. The design is simple, to minimise cost. It must be realised that accuracy and repeatability are important considerations, because any errors will be repeated on the final assembly.

The fixture is designed with two holes in the top face to accept the two plungers. Also, two pins are mounted on the top surface where the contact block is to be located. This means that the two holes for the fixing screw must be accurately positioned and also require a close tolerance on the holes. This request was made to the Assembly Analysis Committee together with recommendations for eliminating certain components. This will be discussed later. In the base of the fixture are two tapped 2BA holes. These are used in conjunction with two set screws to attach the fixture to the platen.

When the fixture is mounted on the platen the accuracy required on positioning is 0.0005 in (0.012 mm), and it is therefore considered that a setting jig will be required on which a transducer is mounted. It is suggested that fixtures be mounted on the platen in the Metrology or Inspection Department to achieve the accuracy required.

Manufacture of Platen and Fixture

High accuracy and repeatability of the platen and fixture, in conjunction with relatively cheap manufacture, was required. It was decided that both parts should be made on a numerically controlled machine tool. In this way the accuracy is determined by the accuracy of the machine tool used. The program used for the cutting sequence was 2CL. Appendix II contains the program and the cutting sequence required for the platen.

6.0 Platen Lifting Mechanism and Fast-Input Mechanism

It has been shown that a mechanism is required to lift the platens off the conveyor for assembly to be carried out.

When the machine cycle time is critical, the platen has to be rapidly pulled into the workstation from the buffer stock. This is carried out with the fast-input system, and was considered more suitable than to increase the conveyor speed to achieve the same result. The reasons were:-

- a) larger horse-power motor required
- b) wear rate increased on platens and slats
- c) heat induced between conveyor and platen causing inaccuracies.

It should be realised that only the slowest work station of the machine should need a fast-input mechanism.

The path of the platen through a work station can be categorized as follows:-

- a) the platen is arrested in a buffer stock prior to the workhead
- b) the platen is released, and allowed to move into the workhead, where it is stopped
- c) the platen is raised to the operating position
- d) after the operating sequence, the platen is returned to the conveyor
- e) the platen is released, and allowed to move into the next buffer stock.

The buffer stock has to be as close to the work head as possible, thus minimising the time taken for the platen to move into the working position. It is apparent that the time taken for the platen to move into position is dependent upon the conveyor speed and distance. If the fast-input mechanism is used, the time taken is dependent upon the motivation speed and distance.

When the movement of the platen through the slowest work station is considered, the following operations are to be performed:-

- a) the platen is arrested in a buffer stock, prior to the work head.
- b) the buffer stop is removed, to allow the platen to be motivated in to the work head.
- c) the station stop arrests the platen beneath the work head.
- d) the platen is raised to the operating position.
- e) following the operating sequence, the platen is returned to the conveyor.
- f) the station stop is removed.
- g) the platen is removed from the work area by the fast-input mechanism acting on the following platen.

The system can be divided into three mechanisms:-

- a) fast-input mechanism
- b) buffer and station stop
- c) lifting mechanism.

Fast-Input Mechanism

The requirements of the fast-input mechanism are as follows: engage with the platen, move the platen from the buffer stock to the work head, disengage from the platen then return to collect the next platen.

Two methods of moving the platen into the workstation were investigated:-

- a) the mechanism picks up the platen by moving a lever in an arc.
- b) linear movement.

The latter method was adopted because less space was occupied behind the platen, to allow the mechanism to engage. The recesses in the leading edge of the platen allow this.

The platen lifting mechanism buffer and station stops and fast-input mechanism are attached to the conveyor through a main frame (see fig. AP15).

The mechanism as shown in fig. AP16 moves in the horizontal plane by a force which is applied to the horizontal cranked shaft. When the shaft comes into contact with the end stops, the enclosed springs will be compressed. This causes interaction between two of the four taper faces. This results in a vertical movement of the shaft while the casing remains stationary, thereby engaging or disengaging the vertical shaft from the platen.

Buffer and Station Stops

Reference is made to fig. AP18. The mechanism comprises a main casing which supports a pneumatic mini-cylinder. Two sliding sleeves are incorporated in the casing. The inner sleeve is screwed to the ram of the pneumatic cylinder, and a pin which passes through the central axis of the sleeve, engages in a slot in the outer sleeve. The inner sleeve is spring loaded with respect to the outer sleeve so that the pin is always loaded towards the left hand end of the slot. This spring can be adjusted to change the force that is exerted by the plunger in the outward direction. This spring-loaded system is necessary because the permissible force of the plunger when locating in the platen is considerably less than the force required to withdraw the plunger when a large buffer stock exists.

As shown in fig. AP18, the station and buffer stops are offset to allow for engagement in the correct position.

Platen Lifting Mechanism

Reference is made to fig. AP19. Platen lift is obtained from a pneumatic jack acting on a 'Y' plate. Thus, motion is transferred through vertical shafts, which slide in linear ball races, to a pair of top plates in which are mounted three kinematically locating hemispheres.

The system is versatile because the pneumatic jack can be matched to the maximum load that will be applied to the platen.

Assembled Workhead Mechanisms

Figures AP20, AP21, AP22 and AP23 show respectively, the side elevations, and plan view of the complete workhead assembly, with and without the fast-input mechanism.

It may be that, for the assembly of the contact blocks, the fast-input mechanism will not be required. This will require experimental verification.

7.0 A General Study of Fixing Heads

Information on the specific features of fixing heads is available mainly in the form of manufacturers sales brochures. These usually give very little insight into the principles of operation, and it was considered by the Committee that an appreciation of this aspect of automatic assembly is important. This is so that a broad view of the problems that are involved can be obtained, and solutions will then be more readily attained. The following section is aimed at providing this information, particularly with reference to the fixing heads which would be required for the assembly of the contact block. Sources of information are given in the bibliography.

The fastening together of the correctly placed components can involve: riveting, welding, screwing, interlocking, bonding or similar operations. Apart from the essential operation of placing and fastening, certain others are incorporated in automatic assembly for example; counting, inspecting and printing.

The fixing heads of the envisaged assembly machine required for the assembly of the contact block are: foil blocking head, rivet setters, screw runners and a screw pushing head. These heads will be described individually, later in this section. The following is a description of parts placing and ejecting mechanisms.

Fixing heads are usually supplied with associated feeding equipment, therefore a description of this follows.

7.1 Parts Placing

This can be classified into three basic types when used in conjunction with fixing heads.

- a) push and guide
- b) gravity fall
- c) pick and place.

a) Push and Guide Mechanism

These placing units are widely used with fixing heads, but they present two problems. First, the force of gravity must be counteracted by using spring-backed detents, hinged jaws or other means, to retain the part until the pusher can operate. Second, the parts must be guided during pushing to avoid jamming.

A method of achieving the desired result is to shape the pusher to the configuration of the part, either internal or external, thereby moving the guide and part together. It is sometimes necessary to provide stationary guides. However, such guides must be designed with sufficient clearance to permit free movement of the part, during its traverse to the fixing positions, without allowing tilting or tipping.

b) Gravity Fall Placing

This is the least expensive, but the most difficult placing method to apply properly. Parts placement depends on gravity and friction forces, and there can be little or no control over the rate of fall of the part. Successful use of gravity fall depends on the ability of the receptacle to retain the part, adequate clearance being required between the part and the receptacle during fall, and the stability of the part itself. Therefore, it is primarily applicable where symmetric parts are to be fixed.

c) Pick and Place Mechanisms

These are the most elaborate, but the most positive means of placing a part. For full details refer to the Report of the Assembly Analysis Committee (ref. 5).

Combination of basic types are also quite frequent, particularly that of gravity fall with a push and guide mechanism to ensure correct location of the part in the assembly.

7.2 Ejecting Mechanisms for Fixing Heads

Ejection units are essentially placing mechanisms in reverse, and their designs fall into one of three general groups:

- a) random
- b) controlled
- c) orientated ejection.

Random ejection is probably the most common method, and is performed in many ways including, blow-off devices using compressed air, wipe-off devices using simple cams, dropping the assembly etc. Parts ejected in this manner are usually dropped into tubes or on to conveyors.

Controlled ejection may be desirable when bulk packaging, continuous marking or similar operations follow. The term, controlled ejection would apply when total specific orientation is not required.

When subsequent operations can be synchronised, it is sometimes desirable to eject an assembly in an orientated position into tubes or tracks. In this case the possibilities of each assembly size and shape must be examined.

7.3 General Description of Fixing Heads used for the Assembly of the Contact Block

Automatic Foil Blocking

In simple terms, Blocking can be defined as, the process of releasing the metal or pigment from a stamping foil. The transfer of the metal or pigment is carried out by applying a heated block to the material to be printed.

The basic principles required of the machine are:-

- a) method of attaching a block or type
- b) method of applying pressure
- c) method of heating the "platen"
- d) method of applying the foil to the component
- e) method of feeding the foil.

Automatic Rivet Setter (Ref. drg. AP24)

A rivet setting machine essentially consists of three components, namely:-

- a) the driver
- b) jaws
- c) roll sets.

The Driver

The driver is located in the ram or spindle of the machine. The working end of the driver is formed to the contour of the rivet head.

The Jaws

The jaws are fastened to a sliding member adjacent to the driver. They are usually supported by a pair of flat springs to allow the rivet and driver to pass through the jaw halves. A rivet is fed to the jaws through a feed track fitted with a suitable part escapement mechanism which deposits the rivet in the jaws at the

start of each riveting cycle. As the cycle proceeds, the driver then continues the descent, pushing the rivet through the two halves of the jaw on to a plunger pin in a roll set.

The Roll Sets

Roll Sets usually consist of three components - plunger, anvil and spring. These parts have a definite relationship to each other and to the rivet. For standard applications, plunger protrusion is equivalent to the length of the rivet. Plunger diameters are normally a few thousandths of an inch larger than the rivet shank diameter. The purpose of the plunger is to pick up and help to centre the rivet correctly in the work. As the driver continues downwards, the plunger pin retracts against spring pressure and guides the rivet through the workpiece until it bottoms against the anvil and is clinched. When the driver and jaws retract, the plunger pushes the rivet and workpiece off the roll set.

Automatic Screw Runner

The basic screw driving mechanism consists of two units:-

- a) supply system
- b) drive mechanism.

a) Supply System

The supply system picks up the headed screws from the vibratory bowl feeder, orientates and feeds them into a driver feed tube.

b) Drive Mechanism

This picks up the screws from the feed tube, inserts them into tapped holes and tightens them to a preset torque. In this process, each screw is placed below the screw driver blade by an automatically controlled gripper. Both the gripper and the driving spindle descend from the pick-up position and while spring loaded jaws open at a preset height each screw is rotated into the tapped hole by means of the screw driver unit. While one screw is driven home, the next one is placed in the pick up position by means of a part escapement mechanism on the feed track.

7.4 Description of Application of Workheads when applied to the Automatic Assembly of the Contact Block

The following is a description of the workheads, previously described, as required for the assembly of the contact block. The workstation number refers to figure AP2 which is the assembly sequence required for the contact block.

Automatic Foil Blocking Head

This is workstation number 2 on the assembly machine. The design of the foil blocking chase and forme is as shown on fig. AP25. The types used, namely N/O and N/C, take the form of a brass engraved plate on the "Platen". Lead slug castings are unsuitable for long runs as the soft metals quickly distort with the application of pressure and heat. The types in the platen (forme) can be fitted in any position by means of spacers, thus making the forme versatile. The types are secured on the chase through the lateral pressure exerted by square key holed quoins. The chase, in turn, is placed on the chase holder for blocking. The heating of the platen is normally done by electrical means through the chase holder and the temperature can be controlled at the optimum of 100 °C by an integral thermostat.

Design of Foil Blocking Head - Figure no. AP26

In the suggested design the workpiece is activated on either side by means of linear force applied through two double acting air cylinders. The piston rod ends are secured to the chase holder by means of flange.

Foil is fed from the unwinder and passes along the low friction lightweight guide rollers and pull roller before it is rewound on the rewinder. The spring loaded pull roller enables the tension of the coil to be controlled, which is vital for the reel fed printing. In addition, a spindle brake is also provided on the unwinder drum.

The rewinder is positively driven for each cycle of operation by means of a roller chain pulley which acquires its rotary motion from the rack and pawl mechanism. This rack and pawl mechanism serves as the means of converting the linear movement into rotary motion as shown in the drawing. The cycle of blocking operation usually takes about 3 secs. for the thermoset materials. This includes the dwell time required to fuse the foil for blocking. Thus the blocking operation on the switch housing continues while the workpieces move from workstation number 2 to 3.

Selection of the Twin-Rivet Setter (Work Station No. 7)

One of the major limitations of a multi-spindle rivet-setter is the minimum centre distance. However, owing to the small shank diameter of the rivets used in the Contact Block, and the rivet centre distances of 0.5 in (12.7 mm), one work station with twin rivet-setter is proposed for the assembly.

Twin rivet setters can be adjusted over a wide range of centre distances, to suit different products, by means of a traverse screw.

Design of Rivet-Setter Workhead (Fig. AP24)

In the proposed twin rivet-setting machine, two tracks are taken from a single vibratory bowl feeder to feed the component into the jaws. A reciprocating release mechanism automatically feeds one rivet at a time, from the feed track to a short section of track leading to a pocket assembly. This assembly contains a step that holds the rivet in place, thus preventing it from falling out of position. Both halves of the pockets are held together by spring slides. The rivet, at this position, is ready to be driven through the work. While the cycle commences, the upper anvil and jaws start moving downwards until the rivet contacts the work. At this predetermined setting, the ram continues downward driving the rivet out of the jaws and on to the lower anvil. The work holding fixture for the switch is provided with two small protruding points on its surface, thus aiding the clinch formation.

The unit is pneumatically controlled and in fact, where brittle materials such as glass, ceramic and thermoset plastics are concerned the rivet setter is preferred to be air driven, since it is provided with a back pressure control valve to accurately limit the clinching pressure.

Layout of Screw Runner Workstations (Drawing No. AP27) (Workstations 8 and 9)

The Committee decided to have two workstations for the assembly of four integral terminal clamp and screws into the contact plate. This is because of the closeness of the centre to centre distance of the screws and also the necessity of assembling widely varying sizes of contact blocks.

Feed Track (Drawing No. AP28)

The terminal clamp and the slotted terminal screw are combined to form an integral component after redesign, to facilitate the assembly in one operation. So, to match the new configuration of the component, a suitable feed track has been designed, enabling the component to move freely along the track in a single file. By gravity and pressure exerted by the successive components, an individual component occupies the pick-up position for the next cycle while one screw is driven home.

Screw Runner Workheads (Drawing No. AP28)

The part geometry plays a vital role in the selection of parts placing mechanism. The pick and place mechanism is preferred for this workhead because of the shape of the component. This mechanism, to its credit, provides the most positive means of placing a part with absolute control over the rate of fall of the part. In the suggested design, spring loaded gripper jaws, and

their holder assembly, swing about a pivot, thus transferring the component from the track to the top stroke position of the unit. Then, the usual cycle of operations follows.

Preset Torque Mechanism

Predetermined torque levels can be obtained by purely mechanical means for the selected torque range, say 15 - 50 psi (173 - 573 Kg/ sq.mm). When a screw has been driven into position its resistance releases a clutch type ball fitted dedent pin, this allows the driving spindle to remain stationary until it is withdrawn from contact with the screw by means of time relay. A sensitive adjustment is provided by means of a spring loaded knurled collar which enables one to achieve a desired preset torque at which the clutch is released. Different ranges of torques can also be obtained by suitable spring replacements.

The workheads can be adapted to assemble the different sizes of the switch, thus making the workstation capable of feeding and driving a wide range of screws at the desired centre distances.

The unit is electrically controlled with integral motor unit.

Design of Workhead for the Assembly of the Fixing Screws (Workstation No. 11)

This is shown on fig. AP29. The original component had been redesigned as shown in fig. AP31, making it possible to push it through the opposite corner holes of the Housing. The contact block is lifted off the Platen in the preceding workstation No. 10, then inspected and fed into a special exit feed track. Thus, at the workstation No. 11, the holes, which are clear of the track, receive the fixing screws from a twin type workhead. The method of operation and placing mechanism are very similar to the twin rivet setter which was dealt with in a previous section.

8.0 Redesign of Contact Block Components

It was a function of each committee of the project to redesign the components of the contact block, if the need arose. The function of the contact block had to remain unchanged by any modification.

As shown in fig. 31, the fixing screw has been modified to eliminate the shake-proof washer and the washer, (see ref. 5). The shake-proof washer was eliminated by specifying serrations to be on the underside of the fixing screw head. It is envisaged that this can be done by a cold-heading method of manufacture. The need for the washer was eliminated by reducing the size of the hole in the Housing. To allow the fixing screw to move freely, the shank diameter was reduced.

The advantages of this redesign are:

- a) when the anticipated production rate is obtained, five million parts will be saved per annum.
- b) by eliminating the need for the feeding equipment that is associated with these components, a substantial saving on the cost of the machine is realised.

9.0 The Machine Layout for the Assembly of the Contact Block.

The general layout as shown in fig. AP2 is based on the assumption that an operator will be required to be positioned adjacent to any one workhead that breaks down. There is a facility for thirteen platens to be in buffer stock between each workstation.

At each of the eleven stations the power requirements are: high pressure air, low pressure air and electricity. For clarity the motor and gearbox has been omitted. It is situated at the wheel adjacent to station 1.

The details of the feeding equipment layout for each workstation may be obtained from ref. 6.

If it is required to reduce the area that is occupied by the machine, then it is apparent that certain workstations can be situated at distances less than 6 ft. (1.83 mm). This has the effect of reducing the maximum number of platens in the buffer stock, but providing this number is maintained at six, then it will be satisfactory. As the workstations are brought closer together, there is a point at which an operator can no longer be placed between adjacent workstations. For the implications and effects of varying buffer stock and having a stand-by manual operator, see ref. 7.

Location of Fixing Heads on Machine

The drawing AP30 shows the overall assembly (part section) view of the conveyor, platen, work holding fixture and the workpiece. The relative position of the fixing workhead is indicated with respect to the workpiece, located on the work holding fixture. The fixture is well secured up on the platen in its matrix of holes. The centre lines of clamping screw runners, fixing screw holes and rivet setters are the lines of operation along which the individual workhead performs the function of fixing the component. In addition, the sides of the switch are 'blocked' by means of the symmetrically placed two air cylinders carrying the printing formes.

10.0 Conclusions

During the investigations that were carried out by the Committee, certain facts became apparent and these are discussed below.

Rotary indexing machines have distinct advantages over free-flow systems where versatility is not a primary requirement. For example, less space is occupied by the machine, the control systems that are necessary are less complex and fewer mechanisms are required to present the assembly at a workhead. Due to these features, the total cost of a rotary indexing machine would be less than the equivalent free transfer system. Generally, the rotary indexing machine is limited to about eight work stations.

The in-line indexing machine provides some of the conditions that are demanded by the requirements of versatility. The two main problems with this system are, returning work holders to the first work head and locating to a high degree of accuracy on large systems.

The proposed system combines the advantages of the various types of systems that are discussed in the report, but it should be realised that the requirements of the assembling company can be met by modifying the system. This can be achieved in many ways. One is the elimination of the space between workheads that allows the substitution of manual operators in the event of a work head breakdown.

It was realised that the fabricated conveyor module was preferable to cast sections because the strength to weight ration was improved. This also allowed for cheaper manufacture of modules with the further advantage that the suppliers of conveyor materials could easily be changed if they proved to be unsatisfactory. This is not always the case with suppliers of castings because they usually retain the casting pattern.

As the conveyor and work stands were designed to be fabricated, the total capital investment in producing the first assembly system would be relatively low.

11.0 Recommendations for Further Work

The Technical Survey Report (ref. 8) established the main requirements for automatic assembly of industrial products. A survey based upon the specific design features of the machine designed at Cranfield is recommended. The survey would be expected to reveal, from the industrial viewpoint, such features as:-

- a) whether or not a 6 ft. (1.83 m) module length is ideal.
- b) the desirability of the machine possessing the facility to operate in two planes.
- c) the maximum load carrying capacity of the platen and lifting mechanism.

The knowledge acquired from a survey would suggest well defined areas for further development on the machine.

It is considered that the power supply lines to workheads should be of modular form and integrated within the structure of the basic module.

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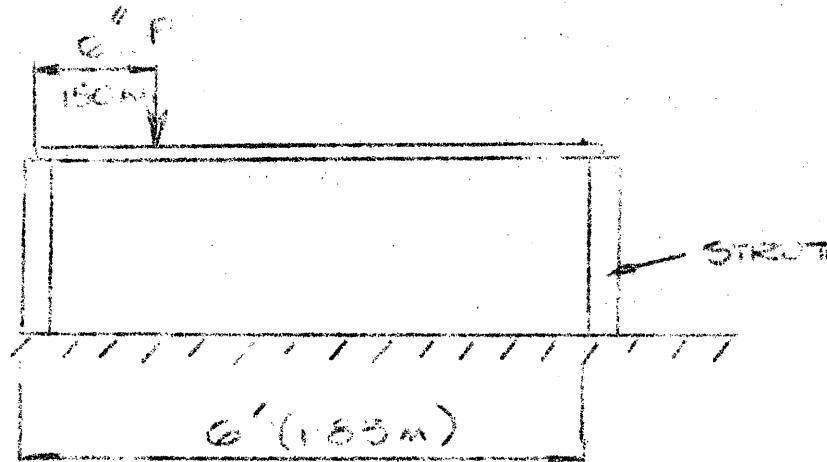
APPENDICES

<u>Title</u>	<u>Appendix</u>
STRESS CALCULATIONS FOR MODULE	I
2CL PROGRAM FOR MANUFACTURE OF PLATEN	II
DETAILS OF COST ESTIMATES AND SUPPLIERS	III

APPENDIX I - 1

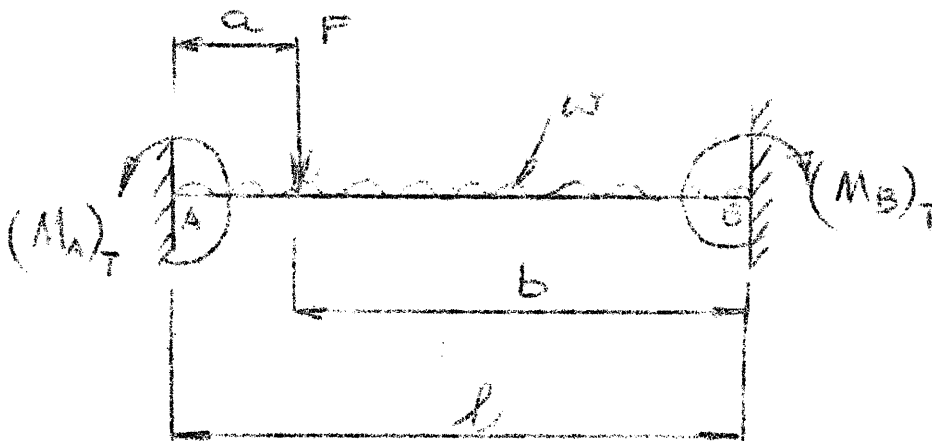
STRESS CALCULATIONS FOR THE MODULE

To reduce deflection and achieve a higher load carrying capacity of the Guide Rail Assembly, a Strut can be added, as appropriate. Taking the worst case of loading which is envisaged, the following set-up is assumed:



The point of application of 'P', (the load applied by a fixing head), will be governed by the position of a lifting mechanism. When a substantial load is to be applied to the platen, the lifting mechanism will always be at the position relative to the Strut as shown above.

Treating the Guide Rail Assembly as an encastré beam:



The distributed load, w lbf/unit length (N/unit length), is obtained by assuming that the Module has platens over its entire length.

Weight of platen = 3.2 lbf (14.2 N)

Weight of assembly and fixture (assumed maximum) = 18 lbf (80 N)

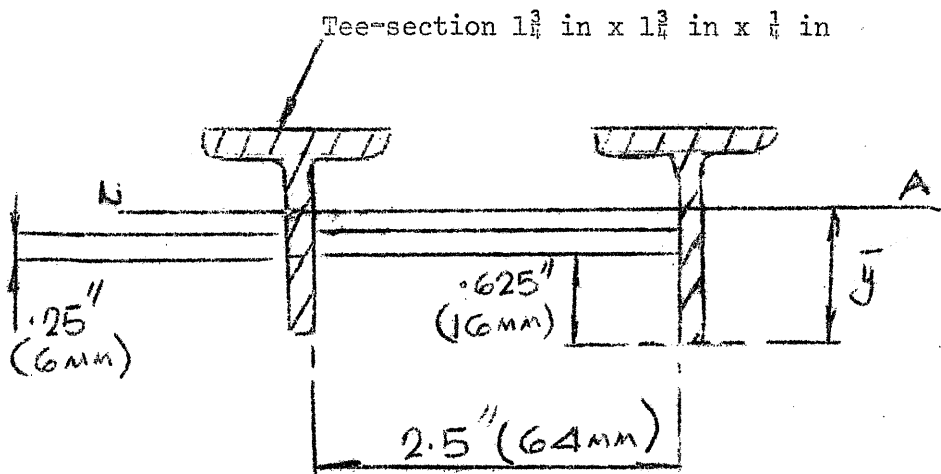
Maximum number of platens on length of module = 13

$$\therefore w = \text{weight/unit length} = \frac{13 \times (3.2 + 18)}{72}$$

$$= 3.84 \text{ lbf/in } (.67 \text{ N/mm})$$

Weight of Guide Rail Assembly /in = .46 lbf/in (.08 N/mm)

Cross Section of Guide Rail Assembly



$$I_{NA} = .661 \text{ in}^4 (28 \times 10^4 \text{ mm}^4)$$

$$\bar{y} = 1.09 \text{ in } (28 \text{ mm})$$

From theory of encastre beams:

Portion of fixing moment due to 'P' = $(M_A)_1$ and $(M_B)_2$

$$(M_A)_1 = \frac{Pab^2}{l^2}$$

$$(M_B)_1 = \frac{Pa^2b}{l^2}$$

Portion of fixing moment due to distributed loads = $(M_A)_2$ and $(M_B)_2$

$$(M_A)_2 = (M_B)_2 = \frac{wl^2}{12}$$

The total fixing moments at 'A' and 'B' are $(M_A)_T$ and $(M_B)_T$ respectively.

$$(M_A)_T = \frac{Pab^2}{l^2} + \frac{wl^2}{12}$$

$$(M_B)_T = \frac{Pa^2b}{l^2} + \frac{wl^2}{12}$$

Now, $ab^2 > a^2b$

∴ Maximum fixing moment = $(M_A)_T$ = Maximum bending moment on Guide Rail Assembly.

$$a = 6 \text{ in (150 mm)}$$

$$b = 66 \text{ in (1.68 mm)}$$

$$l = 72 \text{ in (1.82 mm)}$$

∴ Evaluating, $(M_A)_T = (5.04P + 1650) \text{ lbf in.}$

From $\frac{M}{I} = \frac{\sigma}{y}$ where, σ = maximum ensile stress = 22 tonf/in²

$$5.04P + 1650 = \frac{\sigma I}{y}$$

Substituting the values of σ , I and \bar{y}

$$\begin{aligned} P &= 5,570 \text{ lbf (24.8 KN)} \\ &= 2.5 \text{ tonf.} \end{aligned}$$

$$\therefore (M_A)_T = 30,000 \text{ lbf in (3.4 KN/m)}$$

If 4, 0.5 in (12.7 mm) bolts are horizontally positioned to attach the Guide Rail Assembly to the Strut, then by considering the force reactions in the Strut a stress of 30,000 lbf/in² (207 KN/mm²) is induced in each bolt.

To summarize, if adjacent struts are 72 in (1.83 mm) apart and the fixing head load is applied at a distance of 6 in (150 mm), the maximum load is approximately 5,600 lbf (25 KN).

APPENDIX II - 1

<1.0R68>

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PAGE 1

PARTNO PLATEN

PAGE 1

ERROR FLAGS	SEQ. NO.	INPUT STATEMENT
	1	PARTNO PLATEN
	2	NOPOST
	3	CLPRNT
	4	MACHIN/UFONE,0
	5	REMARK GEOMETRY DEFINITIONS FOLLOW
	6	SETPT = POINT/-3,-1.5,2.11
	7	P1 = POINT/0,0,0
	8	P2 = POINT/6,0,0
	9	L1 = LINE/P1,P2
	10	P3 = POINT/6,4.594,0
	11	P4 = POINT/4.5,5,0
	12	P5 = POINT/1.5,5,0
	13	P6 = POINT/0,4.594,0
	14	L2 = LINE/P2,P3
	15	L3 = LINE/P3,P6
	16	L4 = LINE/P4,ATANGL,90,L3
	17	L5 = LINE/P4,P5
	18	L6 = LINE/P5,PERPT0,L5
	19	L7 = LINE/P6,P1
	20	P7 = POINT/0,2.423,0
	21	P8 = POINT/0,1.531,0
	22	P9 = POINT/0.375,2.423,0
	23	L8 = LINE/P7,P9
	24	L9 = LINE/P9,PERPT0,L8
	25	L10 = LINE/P8,PERPT0,L7
	26	SL1 = LINE/P1,ATANGL,60,L1
	27	L11 = LINE/PARLEL,L1,YLARGE,1.375
	28	SL2 = LINE/(POINT/INTOF,L5,L7),ATANGL,-60,L5
	29	L12 = LINE/PARLEL,L7,XLARGE,0.812
	30	P10 = POINT/INTOF,SL1,SL2
	31	SL3 = LINE/P10,PARLEL,L1
	32	L13 = LINE/PARLEL,L2,XSMALL,1.000
	33	P11 = POINT/1,1,0.125
	34	P12 = POINT/1,4,0.125
	35	P13 = POINT/5,1,0.125
	36	REMARK PATTERN DEFINITION FOLLOWS
	37	PAT1 = PATERN/LINEAR,P11,P12,4
	38	PAT2 = PATERN/LINEAR,P11,P13,5
	39	PAT3 = PATERN/PARLEL,PAT1,PAT2
	40	PL1 = PLANE/P1,P2,P3
	41	PL2 = PLANE/0,0,1,-0.217
	42	PL3 = PLANE/0,0,1,-0.313
	43	PL4 = PLANE/0,0,1,-0.438
	44	M1 = MACRO/
	45	GO/TO,L1,TO,PL4,TO,L7
	46	GORG/TO,L1,PAST,L2
	47	GOLFT/L2,PAST,L3
	48	GOLFT/L3,TO,L4

II - 2

<1.0R68>

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PAGE 2

PARTNO PLATEN

PAGE 2

ERROR FLAGS	SEQ. NO.	INPUT STATEMENT
	49	GORGTL/L4,PAST,L5
	50	GOLFT/L5,PAST,L6
	51	GOLFT/L6,T0,L3
	52	GORGTL/L3,PAST,L7
	53	GOLFT/L7,PAST,L8
	54	GOLFT/L8,T0,L9
	55	GORGTL/L9,T0,L10
	56	GORGTL/L10,PAST,L7
	57	GOLFT/L7,PAST,L1
	58	GOTO/SETPT
	59	TERMAC
	60	M2 = MACRO/
	61	GO/ON,SL1,T0,PL2,ON,L7
	62	GOLFT/SL1,ON,L11
	63	GODLTA/0.5
	64	GOTO/6,2.5,0.5
	65	GODLTA/-0.217
	66	AUTOPS
	67	GOLFT/SL3,ON,L13
	68	GODLTA/0.5
	69	GOTO/0,5,0.5
	70	GODLTA/-0.217
	71	AUTOPS
	72	GOLFT/SL2,ON,L12
	73	GODLTA/0.5
	74	GOTO/SETPT
	75	TERMAC
	76	M3 = MACRO/
	77	GO/ON,SL1,T0,PL3,ON,L7
	78	GOLFT/SL1,ON,L11
	79	GODLTA/0.5
	80	GOTO/6,2.5,0.5
	81	GODLTA/-0.313
	82	AUTOPS
	83	GOLFT/SL3,ON,L13
	84	GODLTA/0.5
	85	GOTO/0,5,0.5
	86	GODLTA/-0.313
	87	AUTOPS
	88	GOLFT/SL2,ON,L12
	89	GODLTA/0.5
	90	GOTO/SETPT
	91	TERMAC
	92	REMARK CUTTING SEQUENCE FOLLOWS
	93	CUTTER/0.475 \$\$0.375 END MILL
	94	FEDRAT/6
	95	FROM/SETPT
	96	CALL/M1 \$\$ROUGHING CUT

<1.0R68>

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PAGE 3

PARTNO PLATEN

PAGE 3

ERROR FLAGS	SEQ. NO.	INPUT STATEMENT
	97	FEDRAT/6
	98	CUTTER/0.375 \$\$FINISHING CUT
	99	CALL/M1
	100	STOP
	101	REMARK CHANGE CUTTER 0.125 DIA SLOT DRILL
	102	FEDRAT/4
	103	CUTTER/0.125
	104	CALL/M2
	105	CALL/M3
	106	STOP
	107	REMARK FIT CENTRE DRILL
	108	FEDRAT/15
	109	CYCLE/DRILL,0.125,3,IPM,0.125
	110	GOTO/PAT3,OMIT,1,4
	111	GOTO/SETPT
	112	STOP
	113	REMARK FIT 0.203 DIA DRILL
	114	CYCLE/DRILL,0.500,3,IPM,0.125
	115	GOTO/PAT3,OMIT,1,4,8,12,17
	116	GOTO/SETPT
	117	STOP
	118	REMARK FIT 0.193 DIA DRILL
	119	CYCLE/DRILL,0.500,3,IPM,0.125
	120	GOTO/PAT3,RETAIN,8,12,17
	121	GOTO/SETPT
	122	REMARK FIT 5MM REAMER
	123	CYCLE/DRILL,0.500,3,IPM,0.125
	124	GOTO/PAT3,RETAIN,8,12,17
	125	GOTO/SETPT
	126	REMARK FIT 0.330 CBORE
	127	CYCLE/DRILL,0.217,2,IPM,0.500
	128	GOTO/PAT3,OMIT,1,4
	129	GOTO/SETPT
	130	END
	131	PRINT/3,ALL
	132	FINI

END OF JOB :- NO ERROR FLAGS : INPUT SECTION TIME =239:52 .

APPENDIX III

DETAILS OF COST ESTIMATES AND SUPPLIERS

<u>Description</u>	<u>Supplier</u>	<u>£</u>	<u>s.</u>	<u>d.</u>
Module per foot length	-	10	0	0
Slat and Link per foot length	Renold Ltd.	1	11	11
17T Horizontal driving wheel - 1 off	Renold Ltd.	8	3	2
17T Horizontal idler wheel - 3 off	Renold Ltd.	14	10	3
Slat bearing material (D.U. Group 2) per foot length of slats	Glacier Metal Company Ltd.	1	2	0
Buffer stops (each)	-	5	0	0
Lifting Mechanism (each)	-	23	0	0
Lifting and motivation mechanism (each)	-	52	0	0
*Platen	-	2	10	0
*Fixture	-	15	0	0
<u>Workstation No. 2</u>				
Printing Workhead and stands	Assembly Process Comm. design	110	0	0
Alternatively: " " "	Elliot Hot printer	160	0	0
<u>Workstation No. 7</u>				
Automatic Impact Rivet-Setter including: vibratory bowl feeder, escapement and feedtrack - 1 off.	Churchill Automatic Assembly, Nottingham	400	0	0
<u>Workstations No's 8 and 9</u>				
Automatic Feed Screwdriver (mark UVS 100) including: vibratory bowl feeder, escapement, feedtrack and stands, 1 off for each station.	Aylesbury Automation Limited	1140	0	0
<u>Workstation No. 11</u>				
Automatic Fixing Screw Driver including: vibratory bowl feeder, escapement and feedtrack - 1 off	Churchill Automatic Assembly	350	0	0

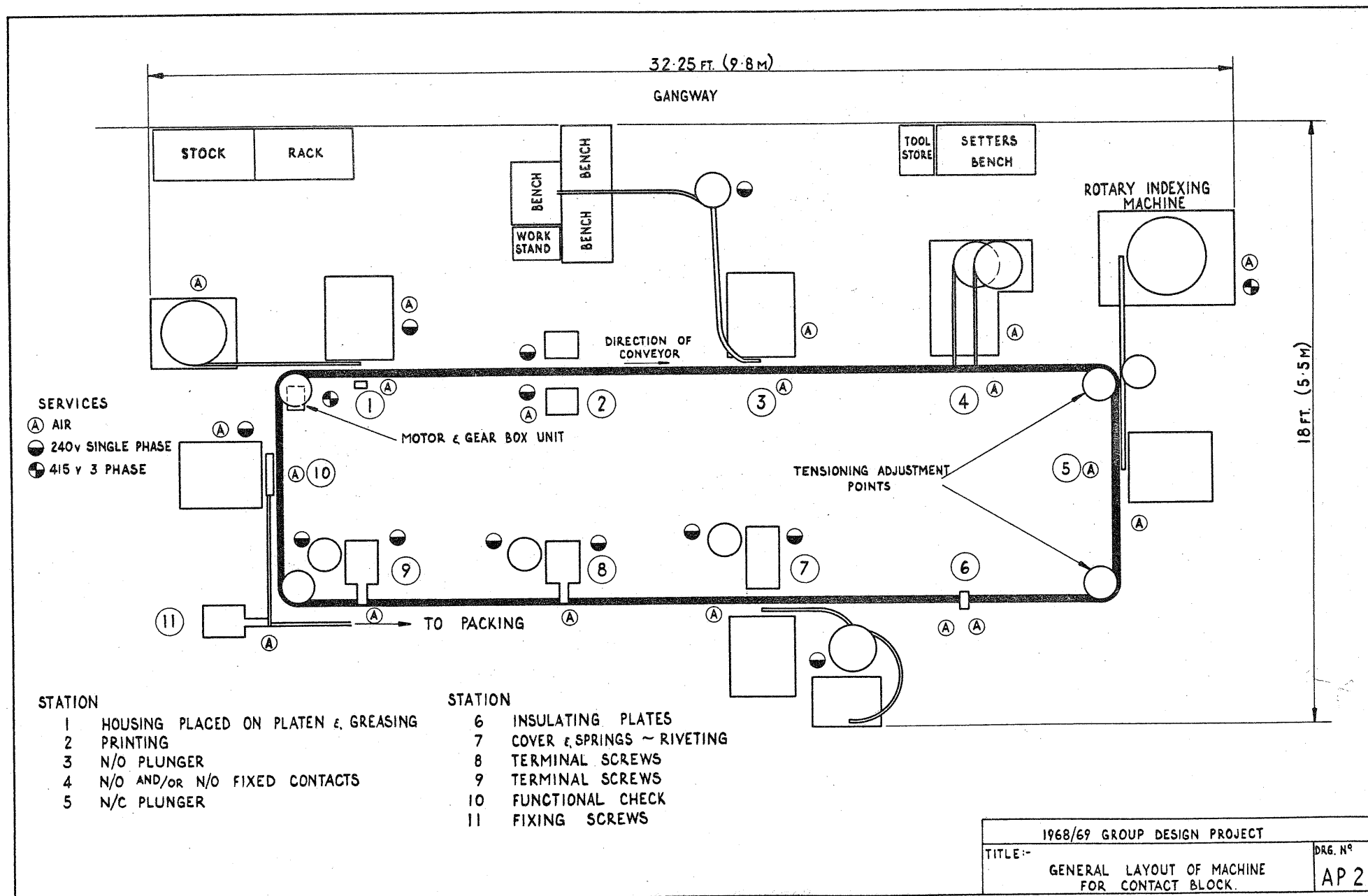
* includes estimate of tape preparation assuming a minimum of 1000 will be produced.

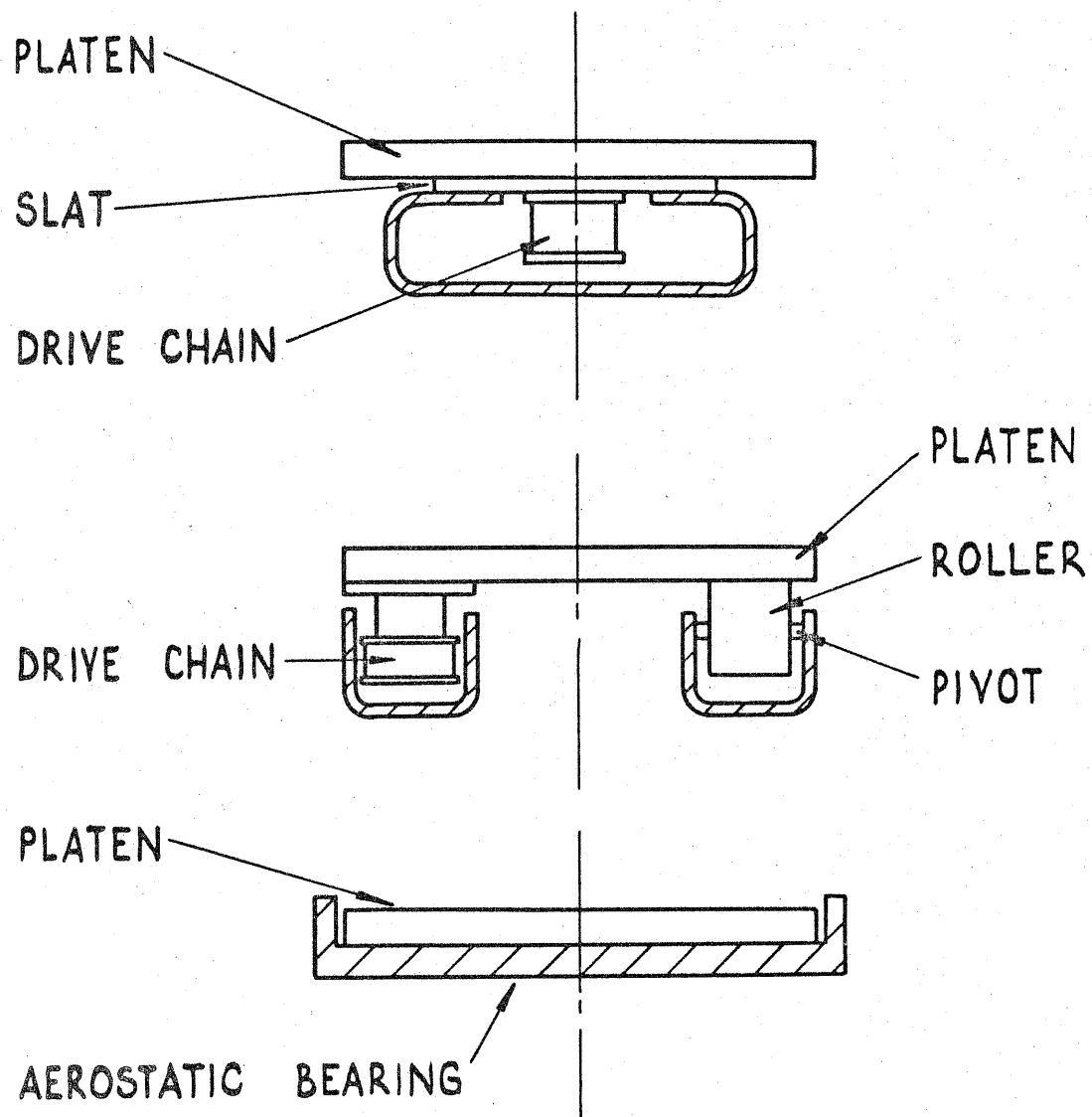
LIST OF FIGURES

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AP5	Basic Conveyor Module
AP6	General Layout of Driving Gear Assembly
AP7	General Layout of Idler Wheel Assembly
AP8	Slat and Link Assembly
AP9	Work Stand
AP10	Platen Fixture and Switch Assembly
AP11	Platen
AP12	Fixture
AP13	Memory Lever Actuation
AP14	Memory Lever Reset Mechanism
AP15	Main Frame
AP16	Fast Input Mechanism
AP17	Complete Fast Input Mechanism
AP18	Buffer and Station Stop
AP19	Platen Lifting Mechanism
AP20	Side Elevation of General Assembly with Fast Input Mechanism
AP21	Side Elevation of G/A without Fast Input Mechanism
AP22	Plan View of General Assembly of Fast Input Mechanism
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AP24	Automatic Twin Rivet Setter
AP25	Forme for Hot Foil Blocking Machine
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AP30	Fixing Head Location for the Contact Block Assembly
AP31	Redesign of Contact Block Fixing Screw

Fig. 1

<u>Types of Assembly Systems</u>	<u>Advantages</u>	<u>Disadvantages</u>
Continuous Transfer	Conveyor Movement Simple.	High inertias in workheads Workhead indexing expensive Workhead indexing speed is difficult to change. Size of system not easily varied.
Rotary Indexing Machine	Work holders are easily returned to 1st Workhead. Limited In-Process float can be obtained.	Limited number of workheads available. Indexing speed not easily changed.
Free Transfer System	Sections can usually be added easily.	Fixture return difficult. Equipment is required to arrest component.
Proposed System (based on free transfer)	Sections can be added easily. Platen positioning is accurate. Cycle time reduced by in-process float.	Equipment is required to accurately position platen.





DIAGRAMS SHOW THREE POSSIBLE
SYSTEMS DERIVED FROM BASIC CONCEPT.

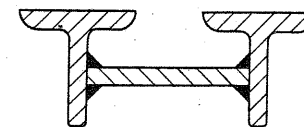
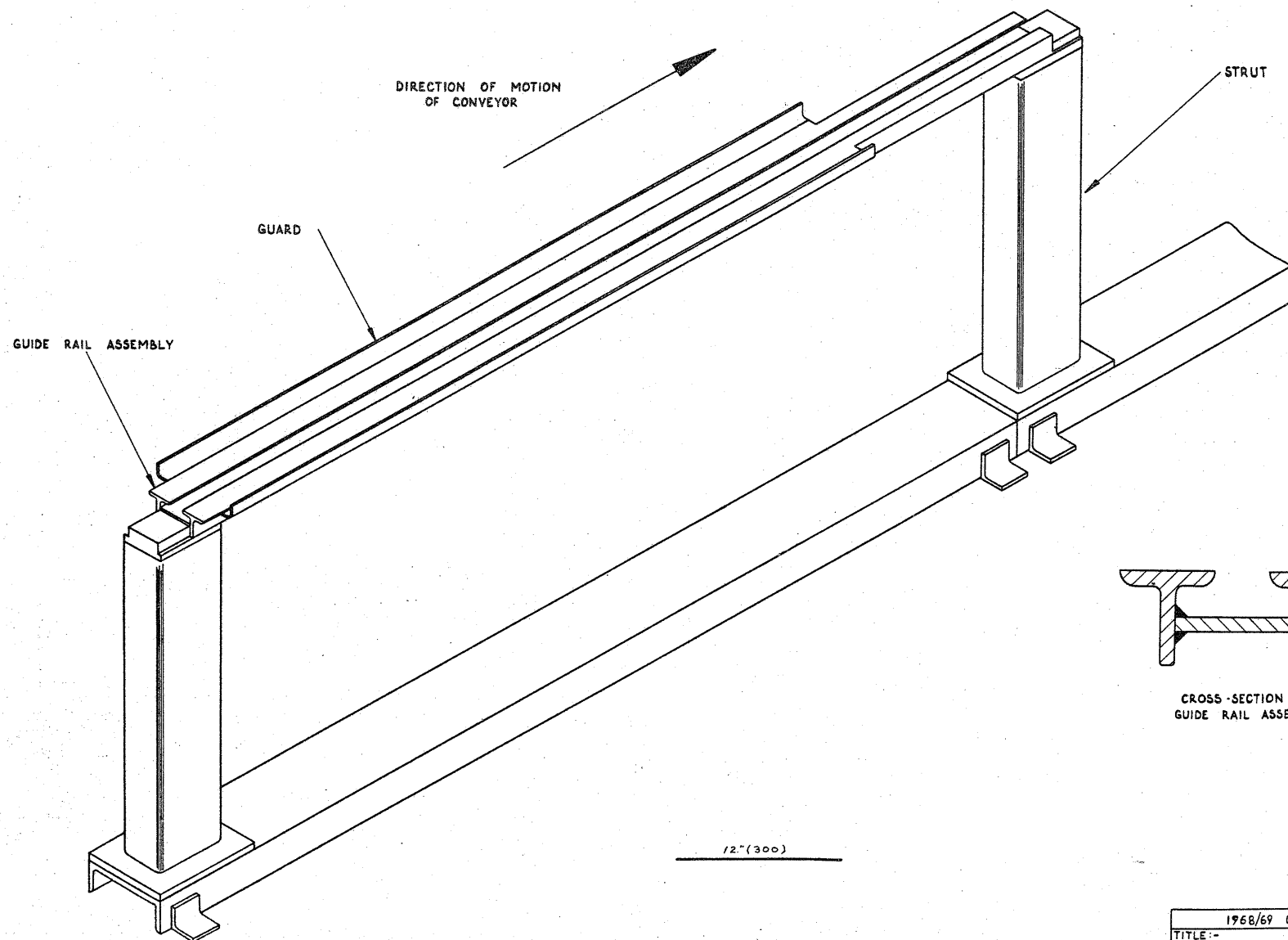
1968/69 GROUP DESIGN PROJECT

TITLE:-

THREE BASIC SYSTEMS

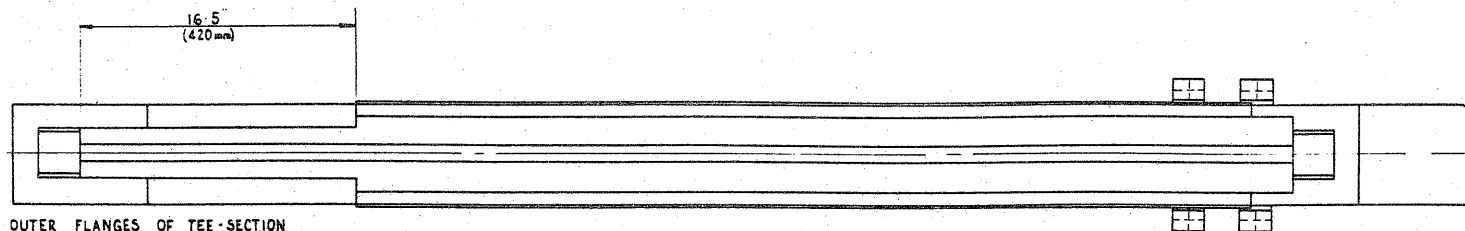
DRG. N^o

AP3

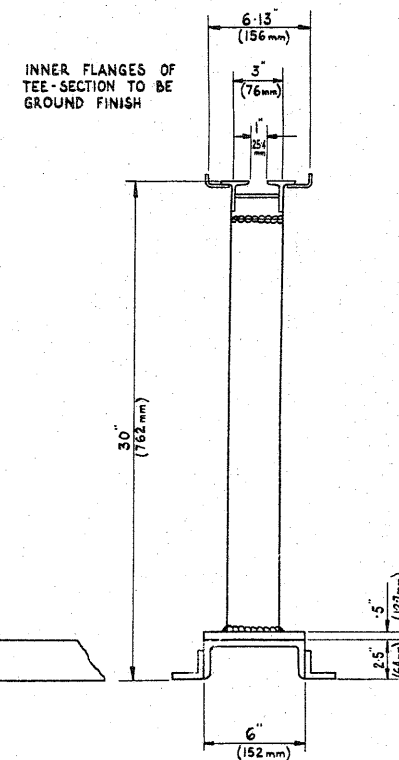
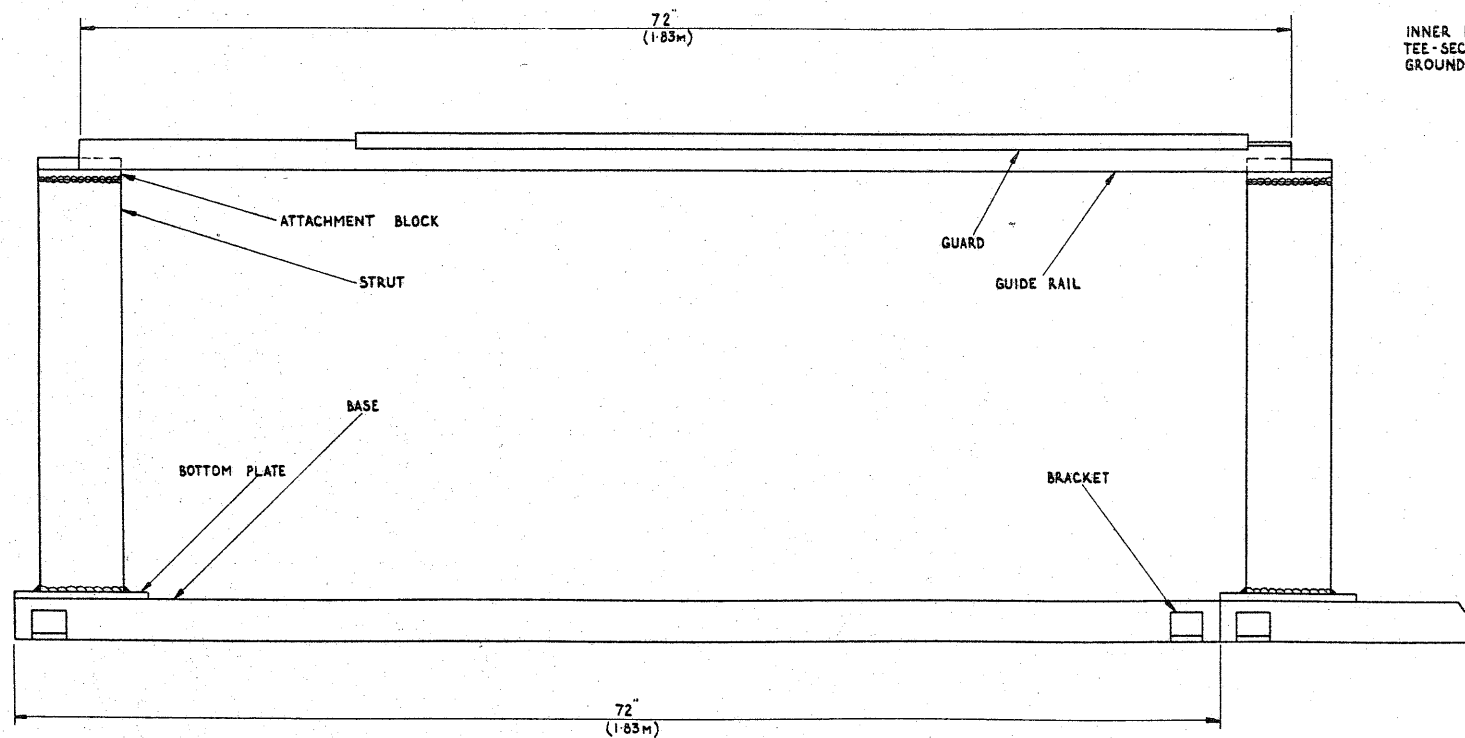


CROSS-SECTION OF
GUIDE RAIL ASSEMBLY

1968/69 GROUP DESIGN PROJECT		
TITLE:-	BASIC CONVEYOR MODULE	DRG. NO AP 4



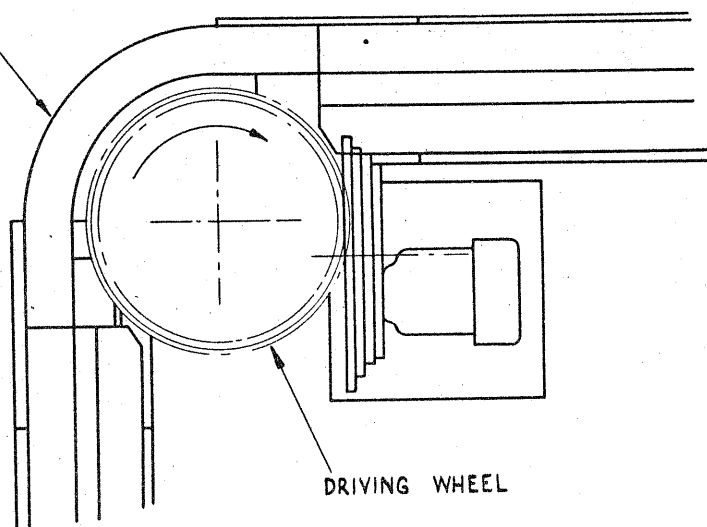
OUTER FLANGES OF TEE-SECTION
REMOVED TO FACILITATE FITTING
OF PLATEN LIFTING MECHANISM.



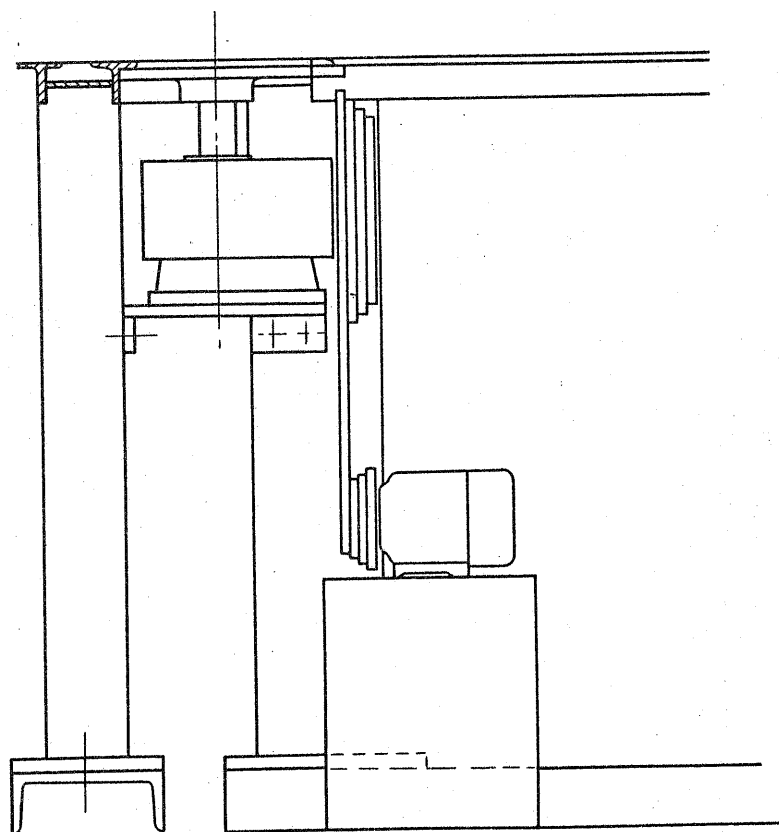
INNER FLANGES OF
TEE-SECTION TO BE
GROUND FINISH

1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG. N ^o
BASIC CONVEYOR MODULE	AP 5

GUARD OMITTED FOR CLARITY



DRIVING WHEEL



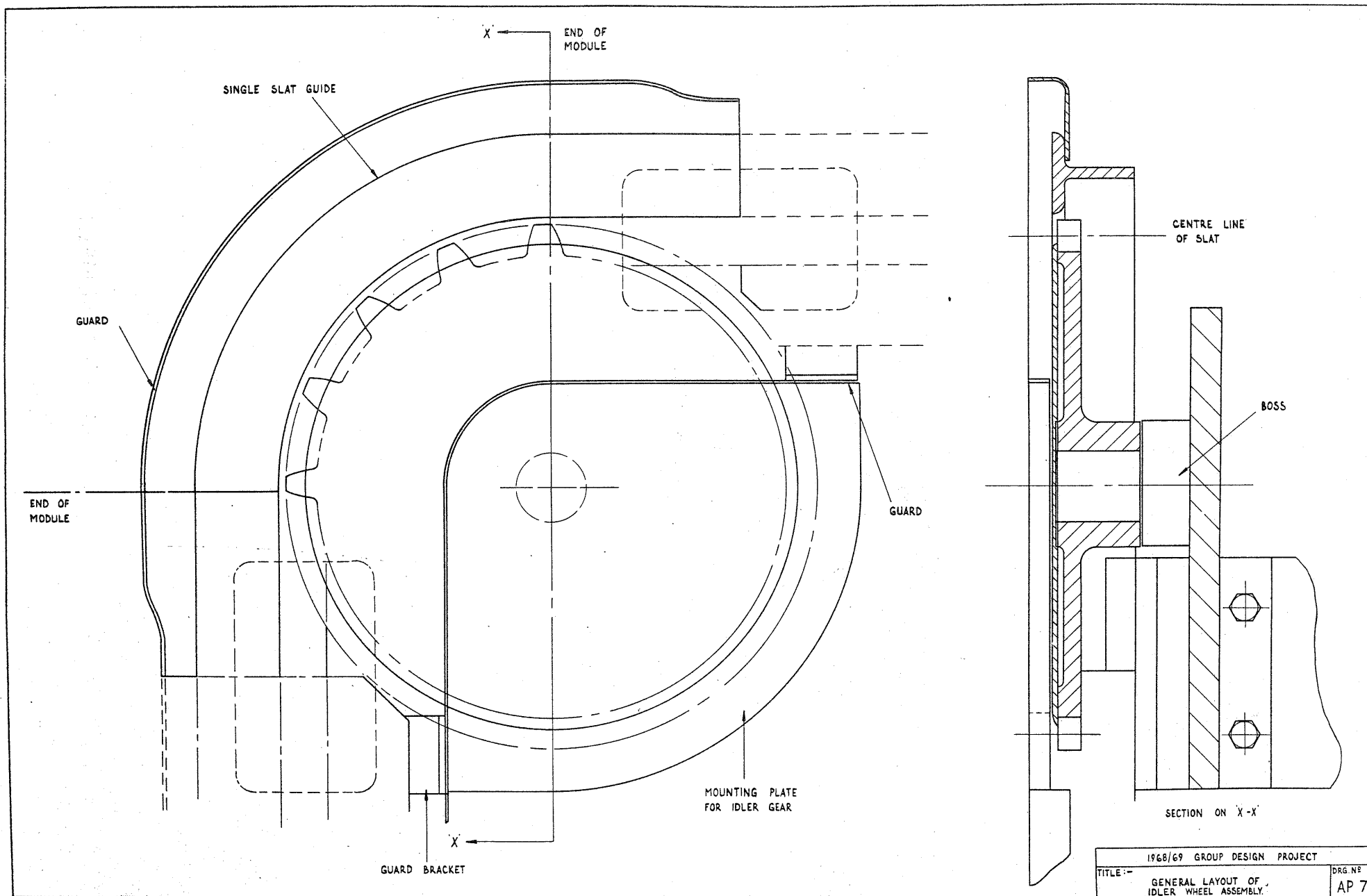
1968/69 GROUP DESIGN PROJECT

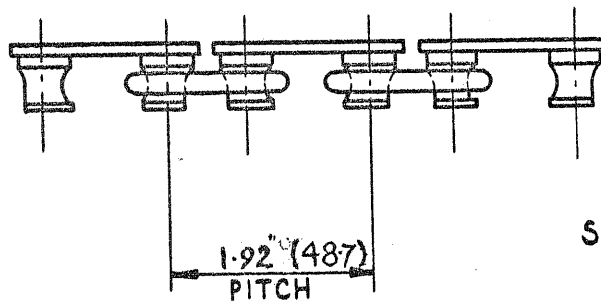
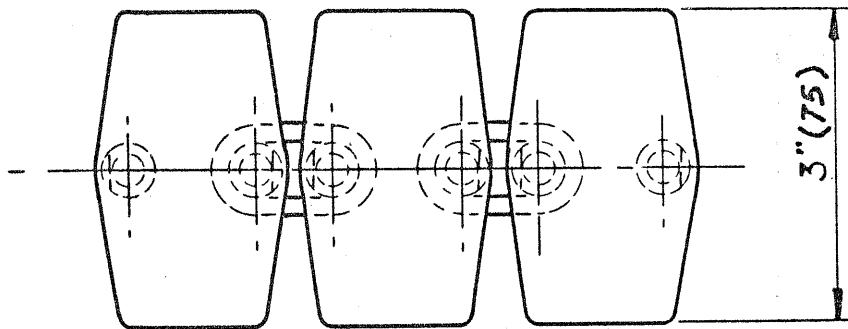
TITLE:-

GENERAL LAYOUT OF
DRIVING GEAR ASSEMBLY

DRG N°

AP 6

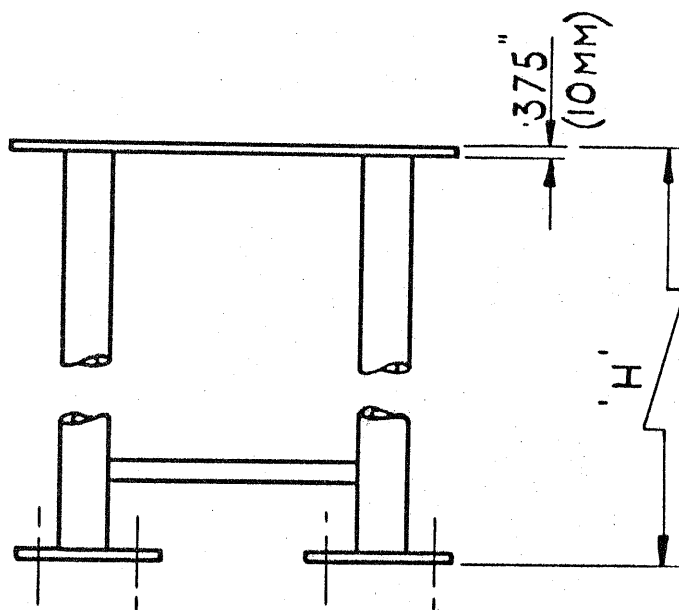
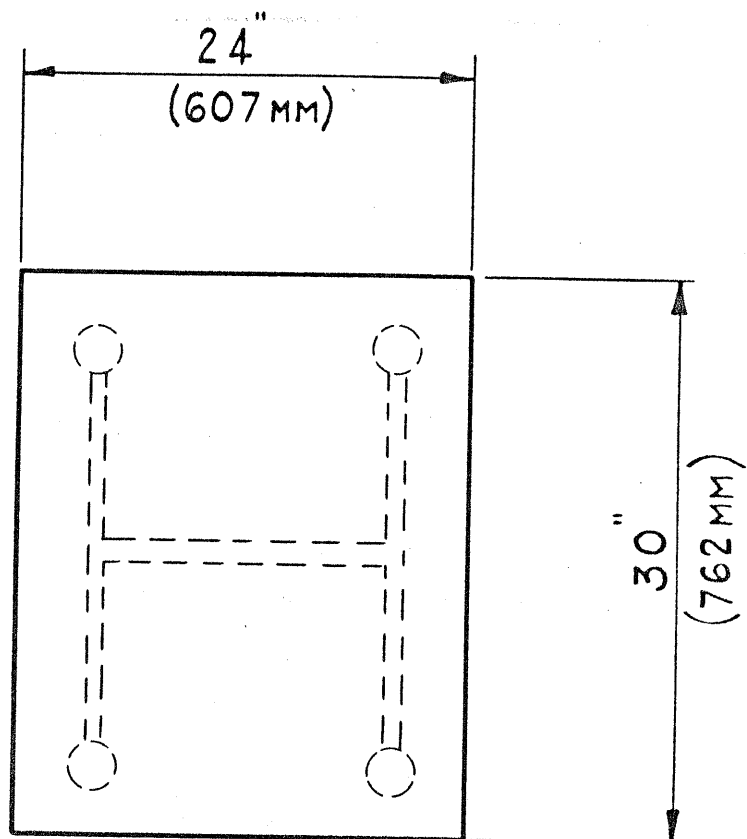




SLAT REMOVABLE

CHAIN IS REQUIRED TO BE SUPPORTED
ON UNDERSIDE.

1968/69 GROUP DESIGN PROJECT		
TITLE :-	SLAT & LINK ASSEMBLY	
		DRG. N° AP 8



HEIGHT 'H' VARIED AS REQUIRED

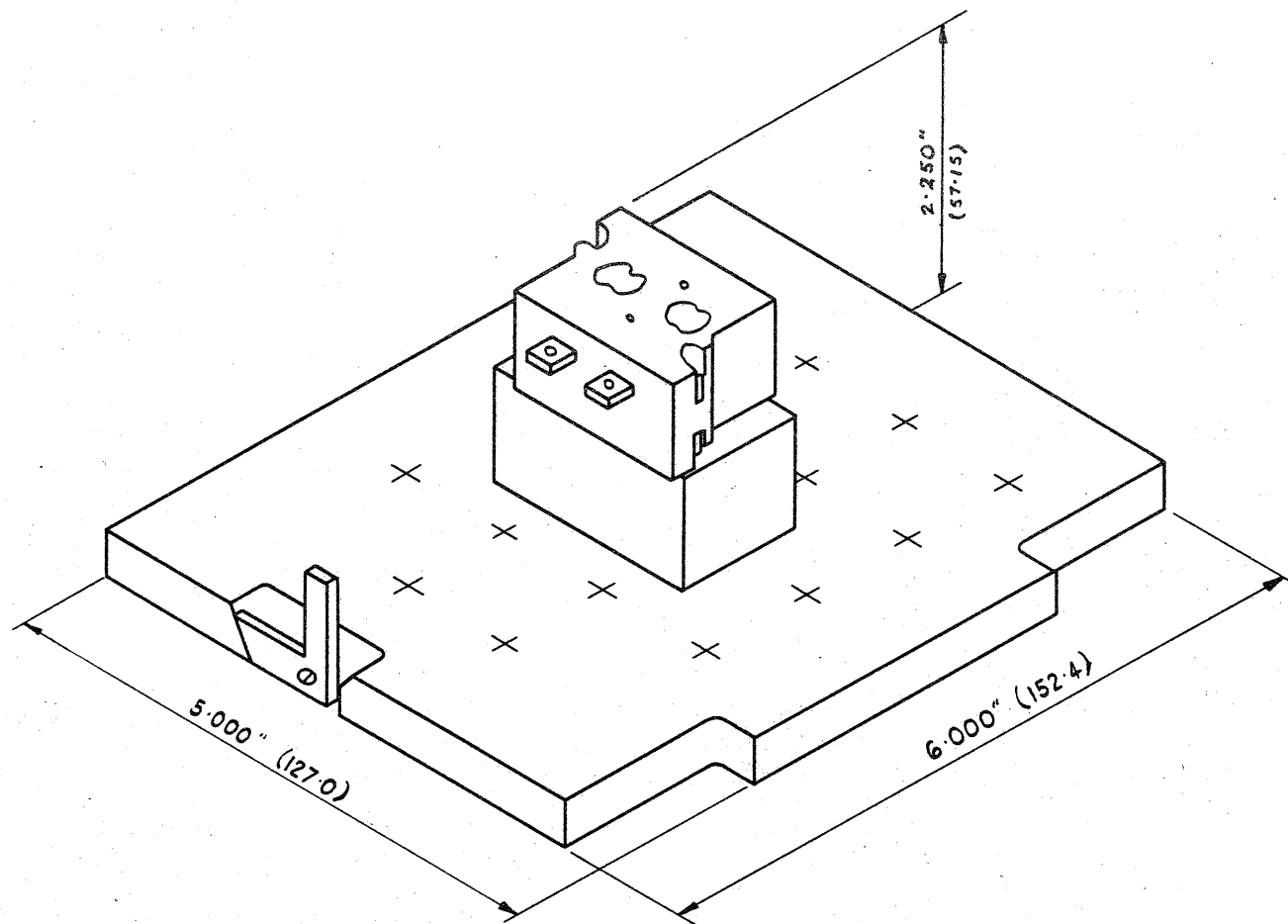
1968/69 GROUP DESIGN PROJECT

TITLE :-

WORK STAND

DRG. N^o

AP 9



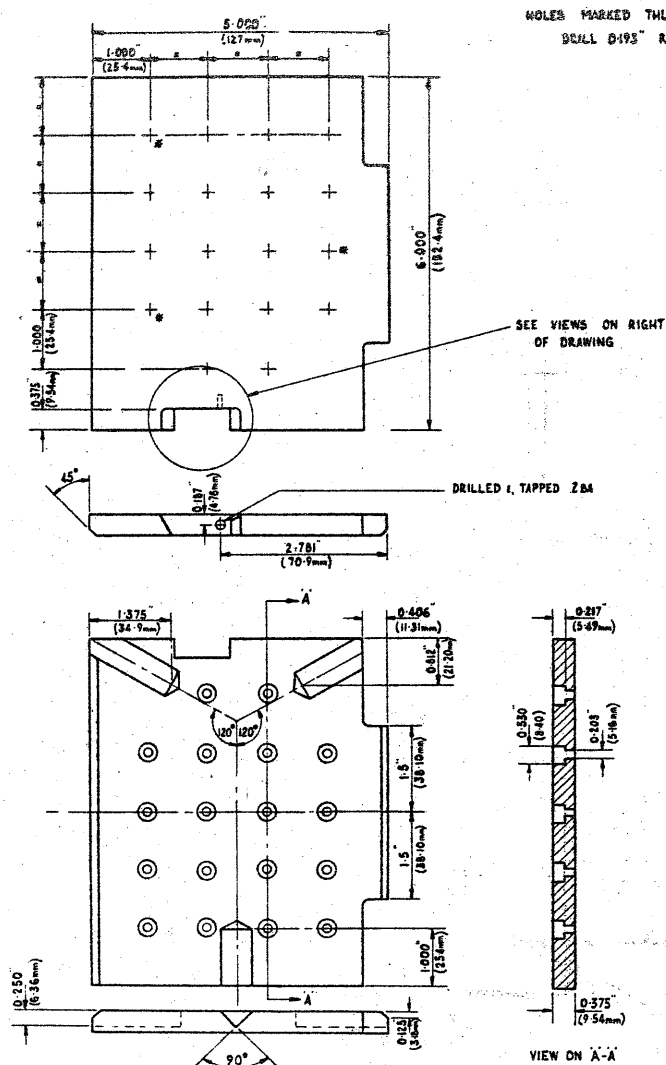
1968/69 GROUP DESIGN PROJECT

TITLE:-

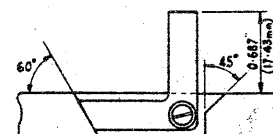
PLATEN FIXTURE & SWITCH ASSEMBLY

DRG. N°

AP 10



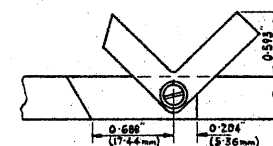
ASSEMBLY VIEW
DOUBLE SCALE



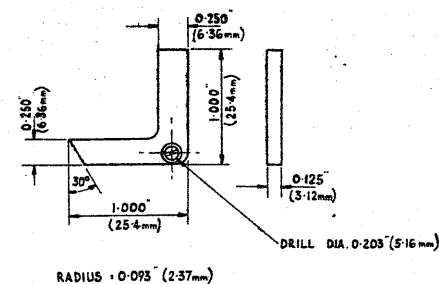
POSITION - ASSEMBLY REJECT

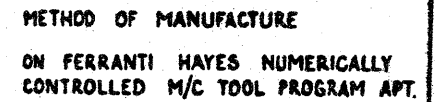
ALL UNSPECIFIED RADII
TO BE 0.187" (4.75mm)

METHODS OF MANUFACTURE
ON FERRANTI HAYES
NUMERICALLY CONTROLLED M/C TOOL
PROGRAM ZCL

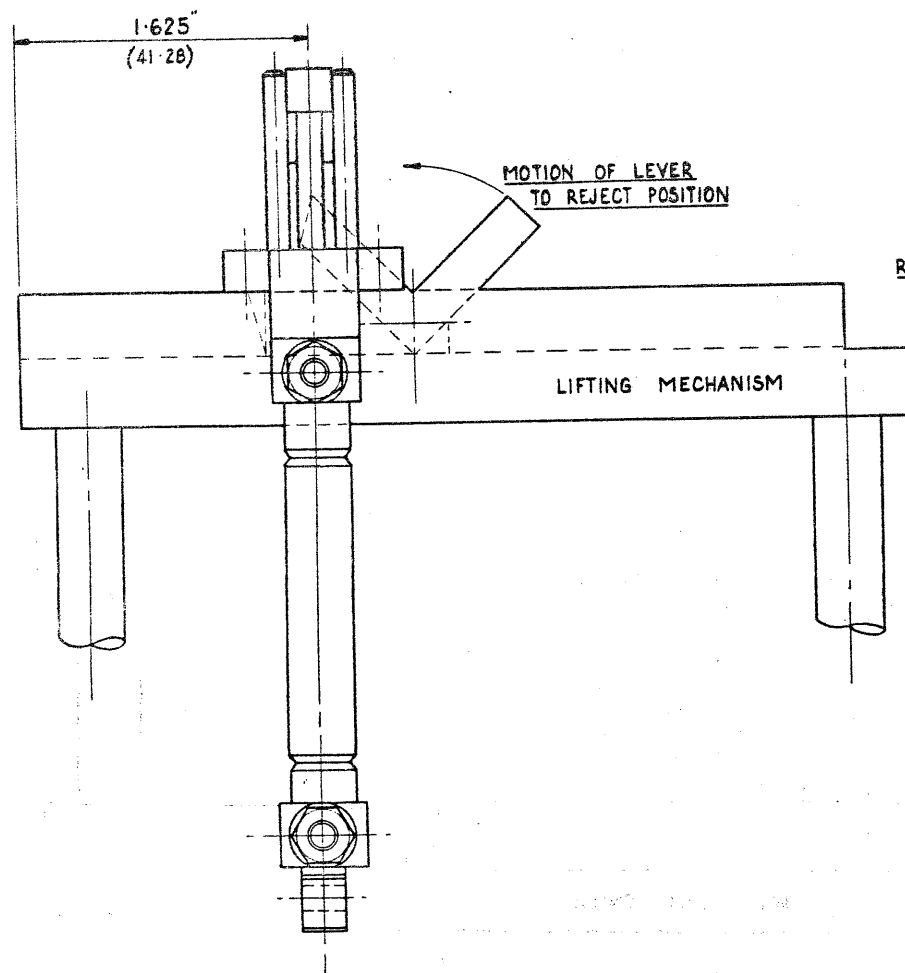


POSITION - ASSEMBLY ACCEPT



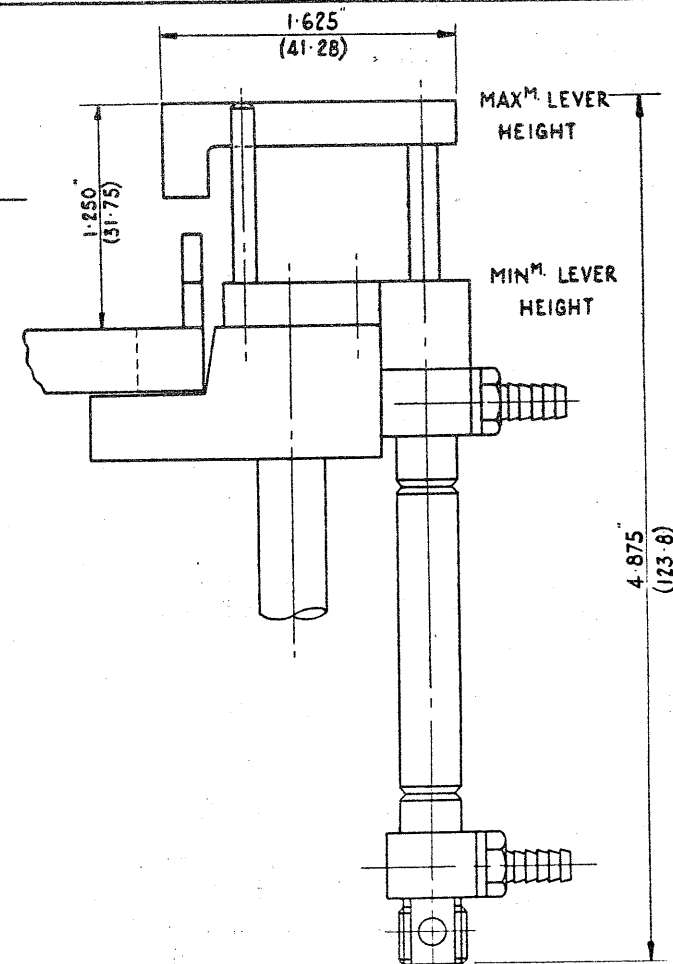


1968/69 GROUP DESIGN PROJECT	
TITLE:- FIXTURE	DRG NO AP 12

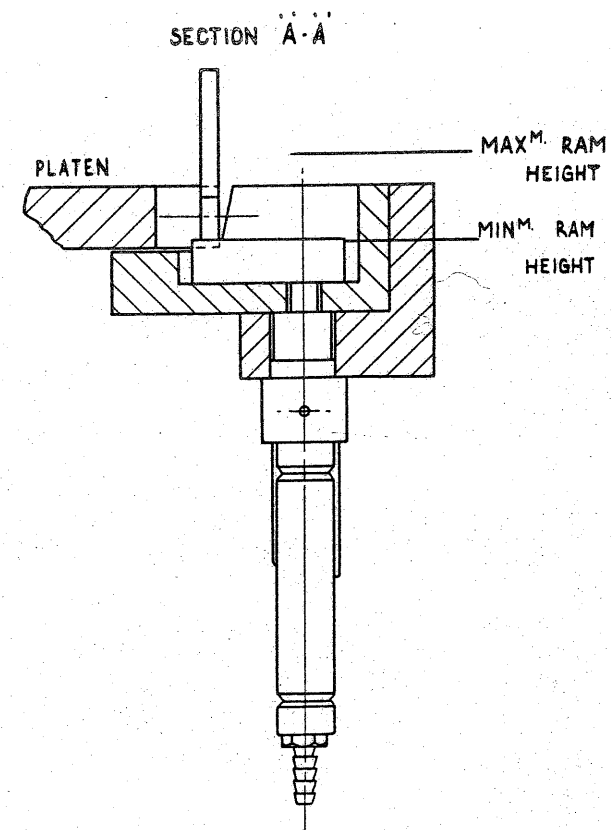
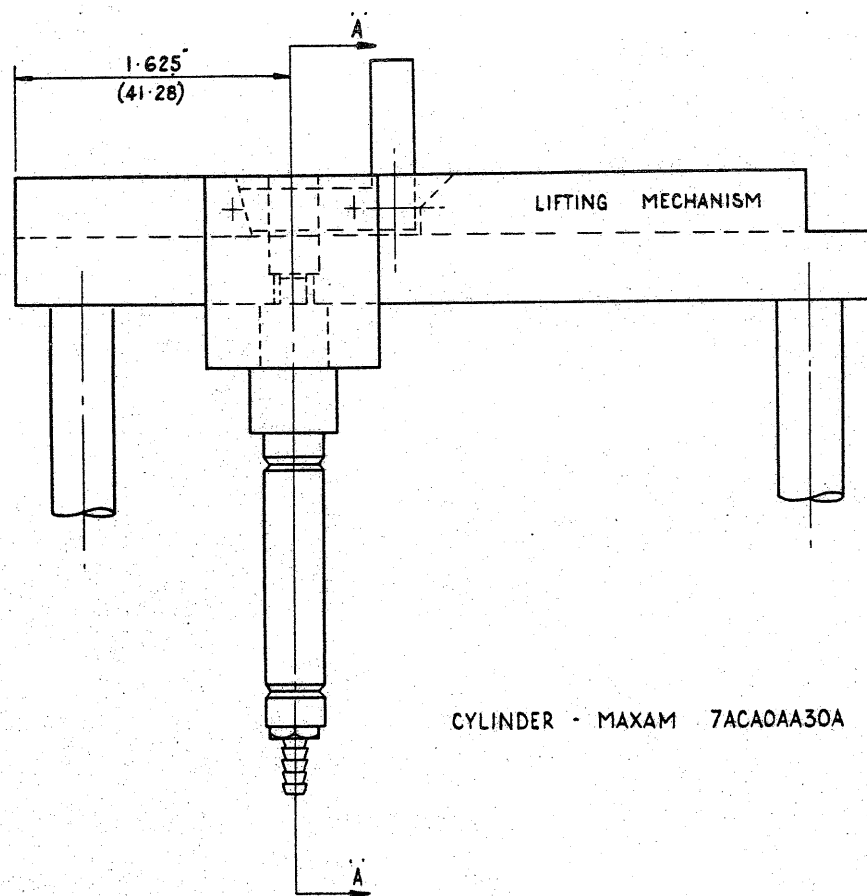


CYLINDER - MAXAM 7ADA0AA 30 C

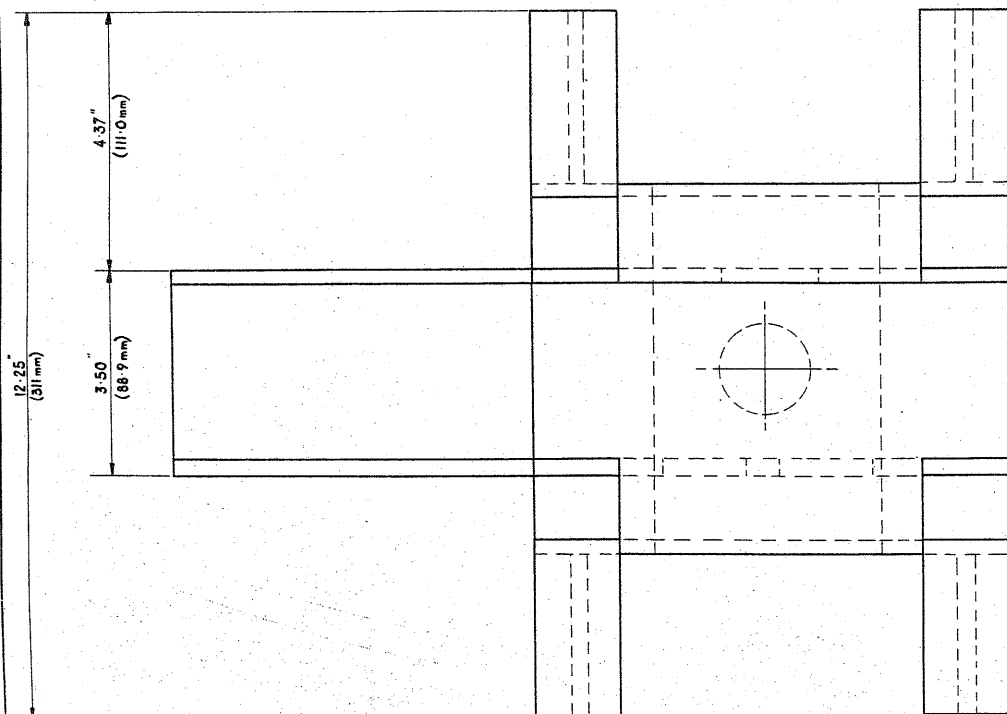
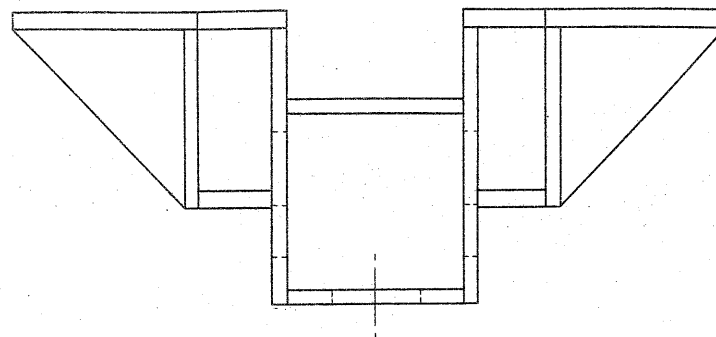
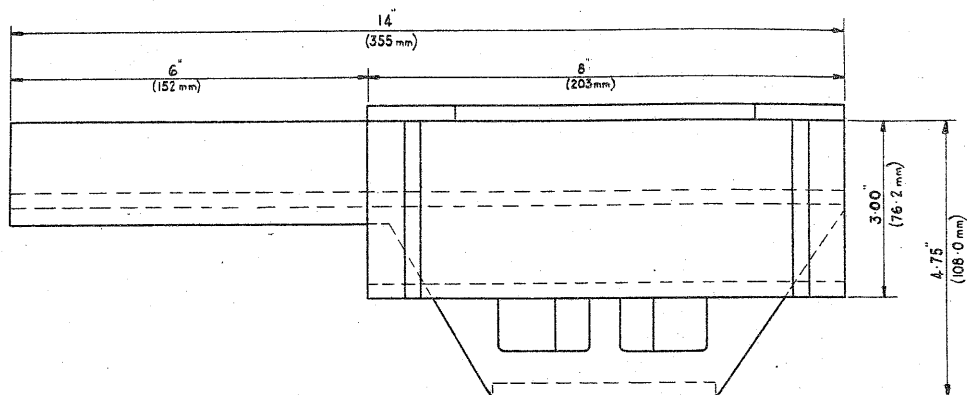
MOTION OF
CYLINDER TO
REJECT POSITION



1968/69 GROUP DESIGN PROJECT	
TITLE -	DRG. N°
MEMORY LEVER ACTUATION	AP 13



1968/69 GROUP DESIGN PROJECT	
TITLE -	DRG. NO.
MEMORY LEVER RESET MECHANISM	AP 14



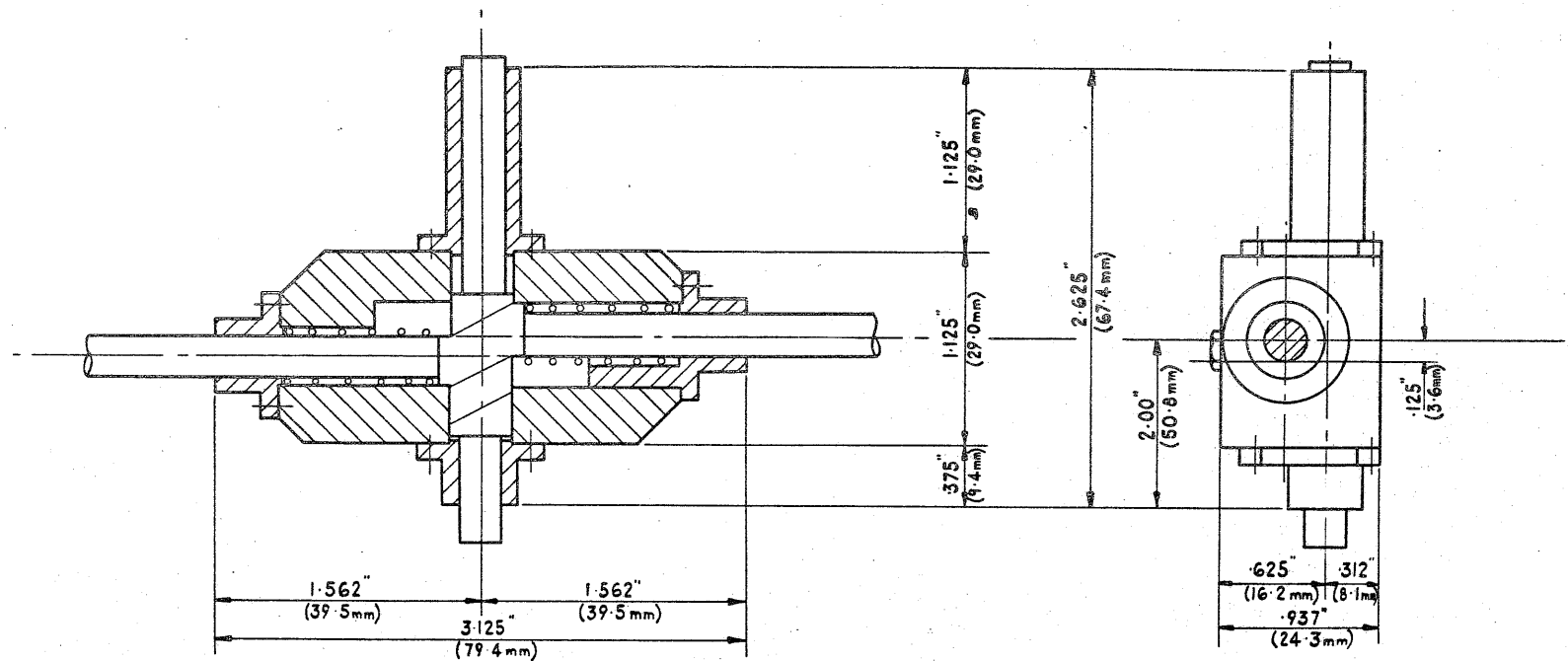
MATERIAL

1/4 M.S. PLATE - WELDED CONSTRUCTION.

REQUIRED

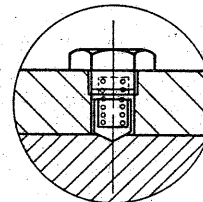
1 OFF PER WORKHEAD.

1968/69 GROUP DESIGN PROJECT	
TITLE :-	DWG. NO.
MAIN FRAME	AP 15

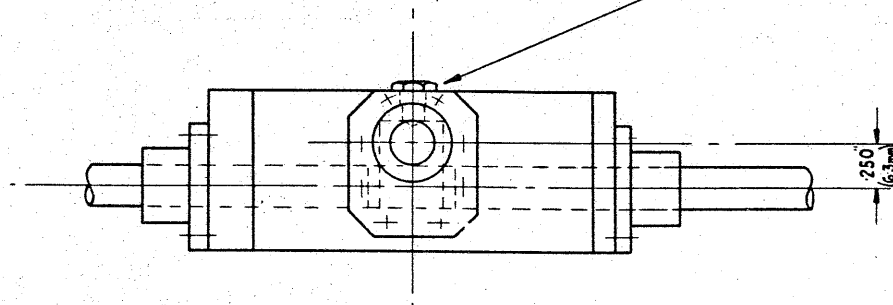


SECTION ON SHAFT C

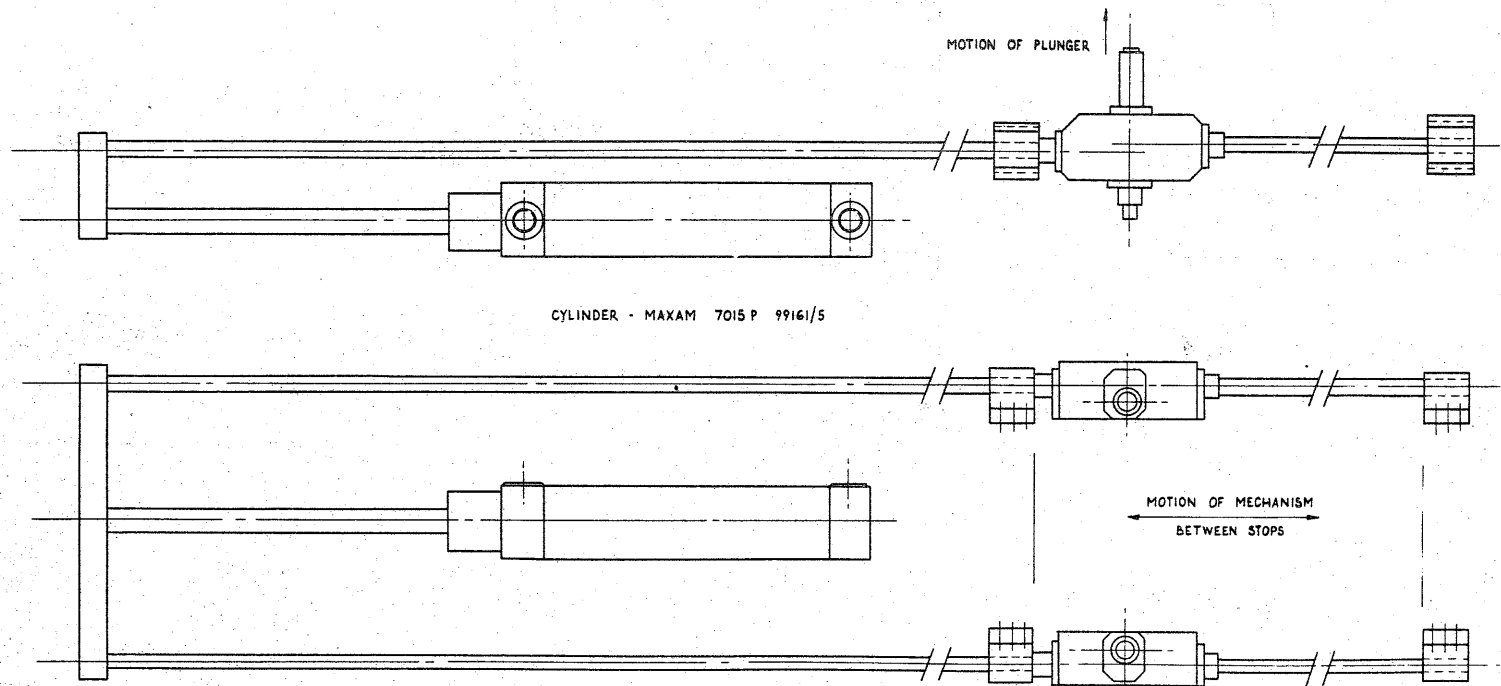
EXPLODED VIEW OF
LOCKING BUTTON



FOR G.A. OF FAST INPUT MECHANISM
REFER TO DRG. AP.17

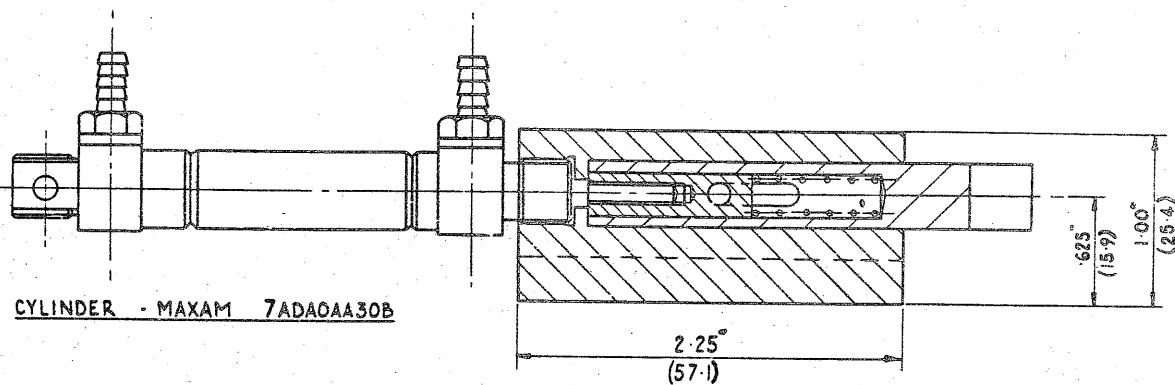


1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG N°
FAST INPUT MECHANISM	AP 16



NOTE - THIS DRAWING IS NOT
TO SCALE

1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG. NO.
COMPLETE FAST INPUT MECHANISM	AP17

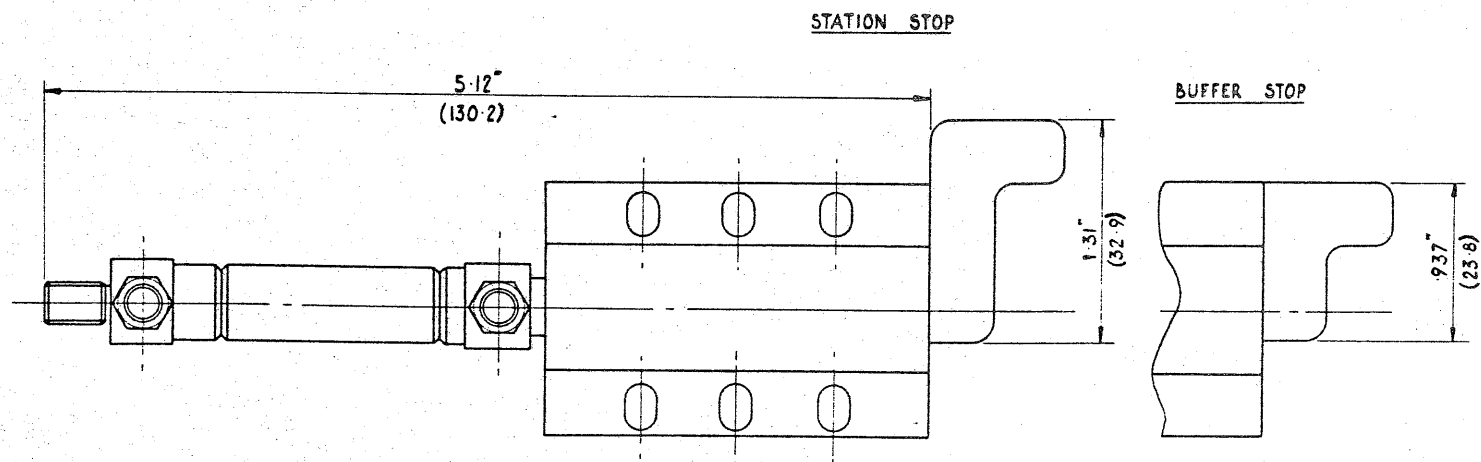


REQUIRED - PER WORKHEAD

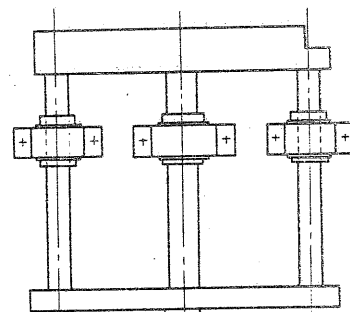
2 STATION STOPS - 1 R.H. & 1 L.H.

2 BUFFER STOPS - 1 R.H. & 1 L.H.

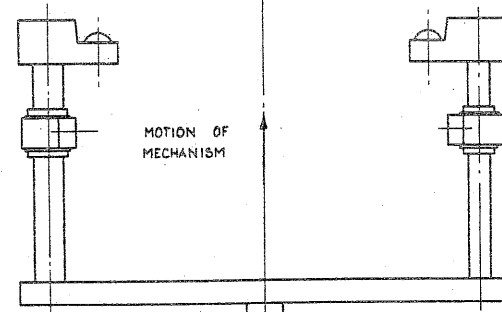
STROKE OF STOPS - $\frac{3}{8}$ " (9.5)



1968/69 GROUP DESIGN PROJECT		
TITLE	DRG NO	
BUFFER & STATION STOPS		AP 18

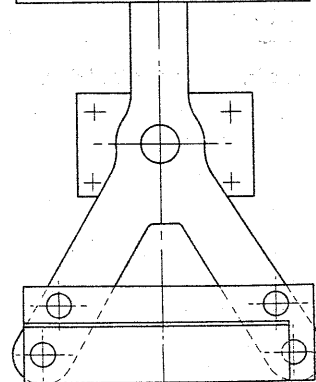
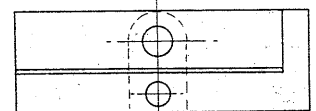
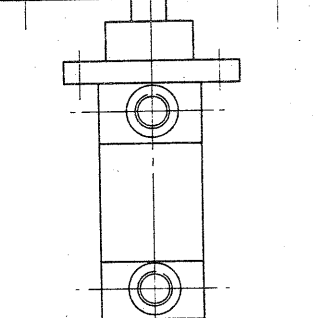


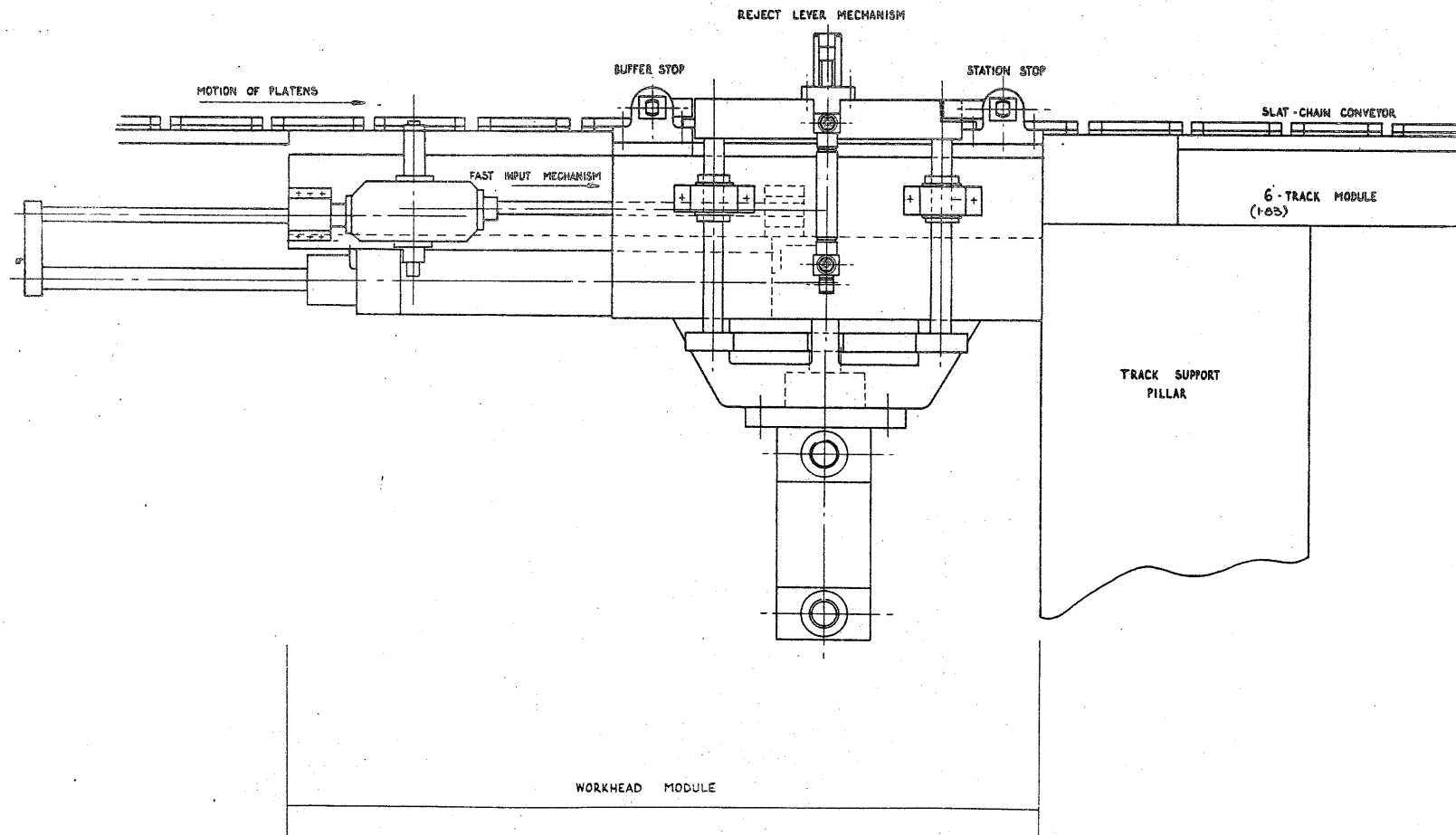
LINEAR BEARINGS



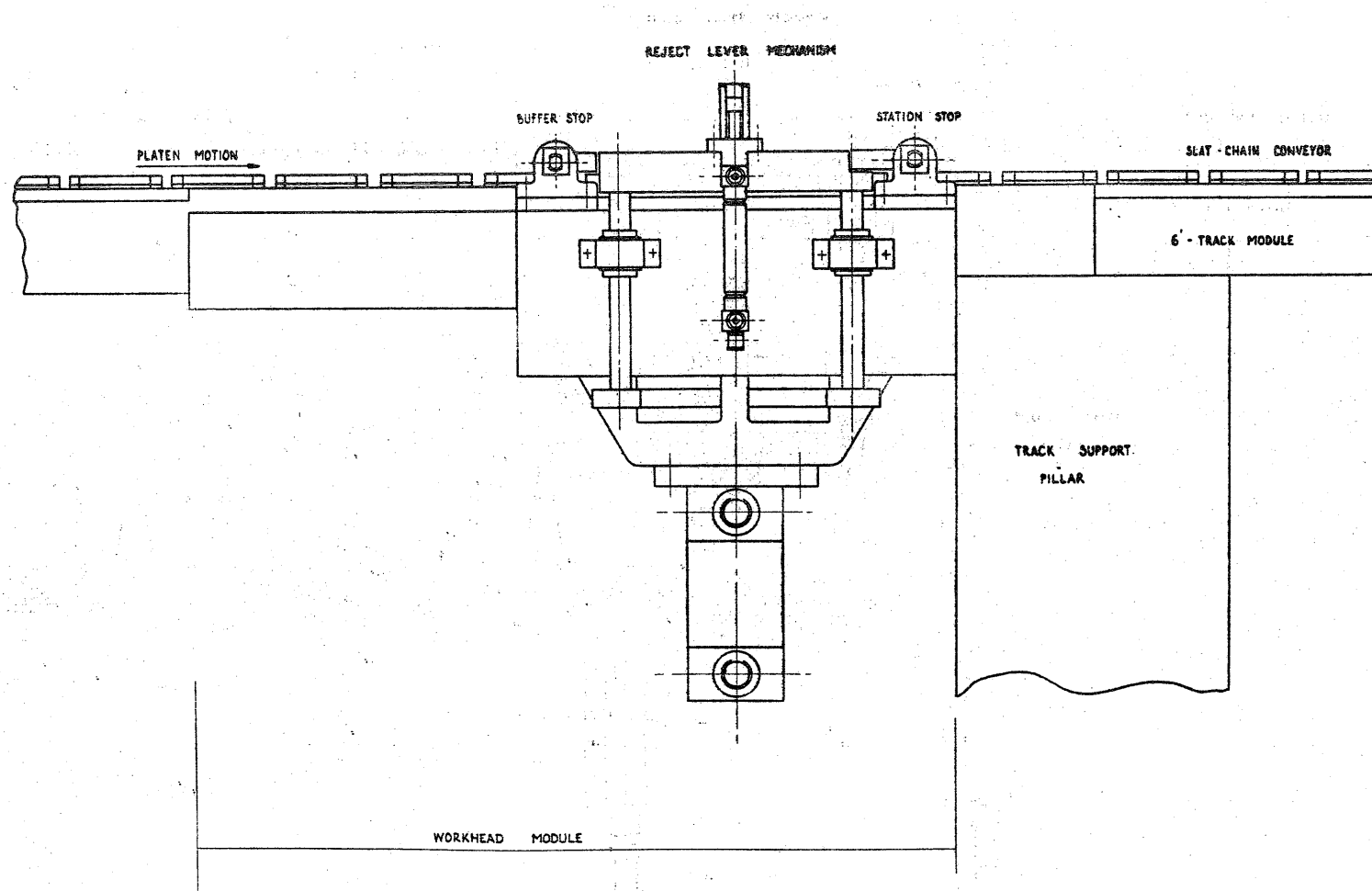
MOTION OF
MECHANISM

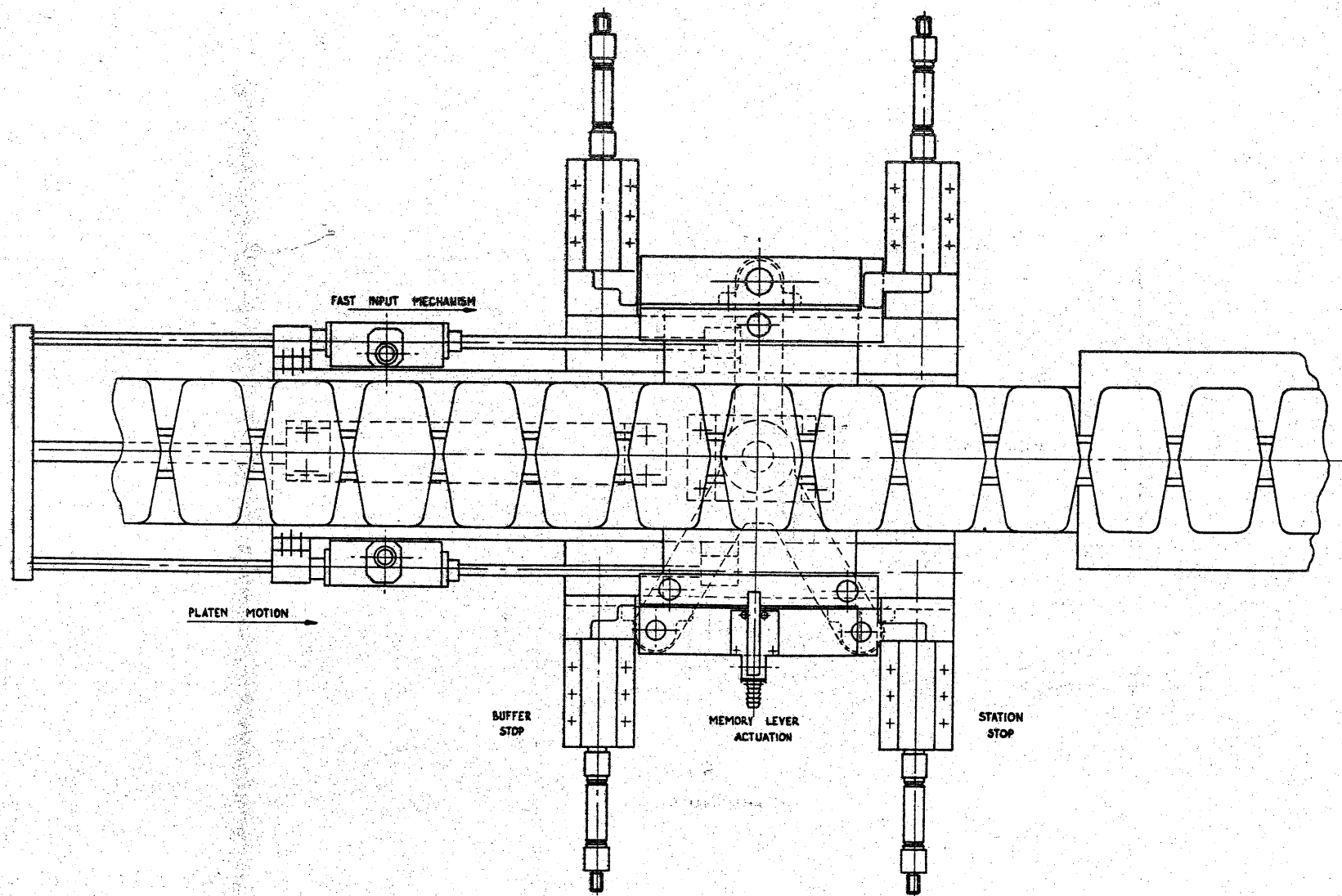
CYLINDER - MAXAM 7015P 99161/3/6





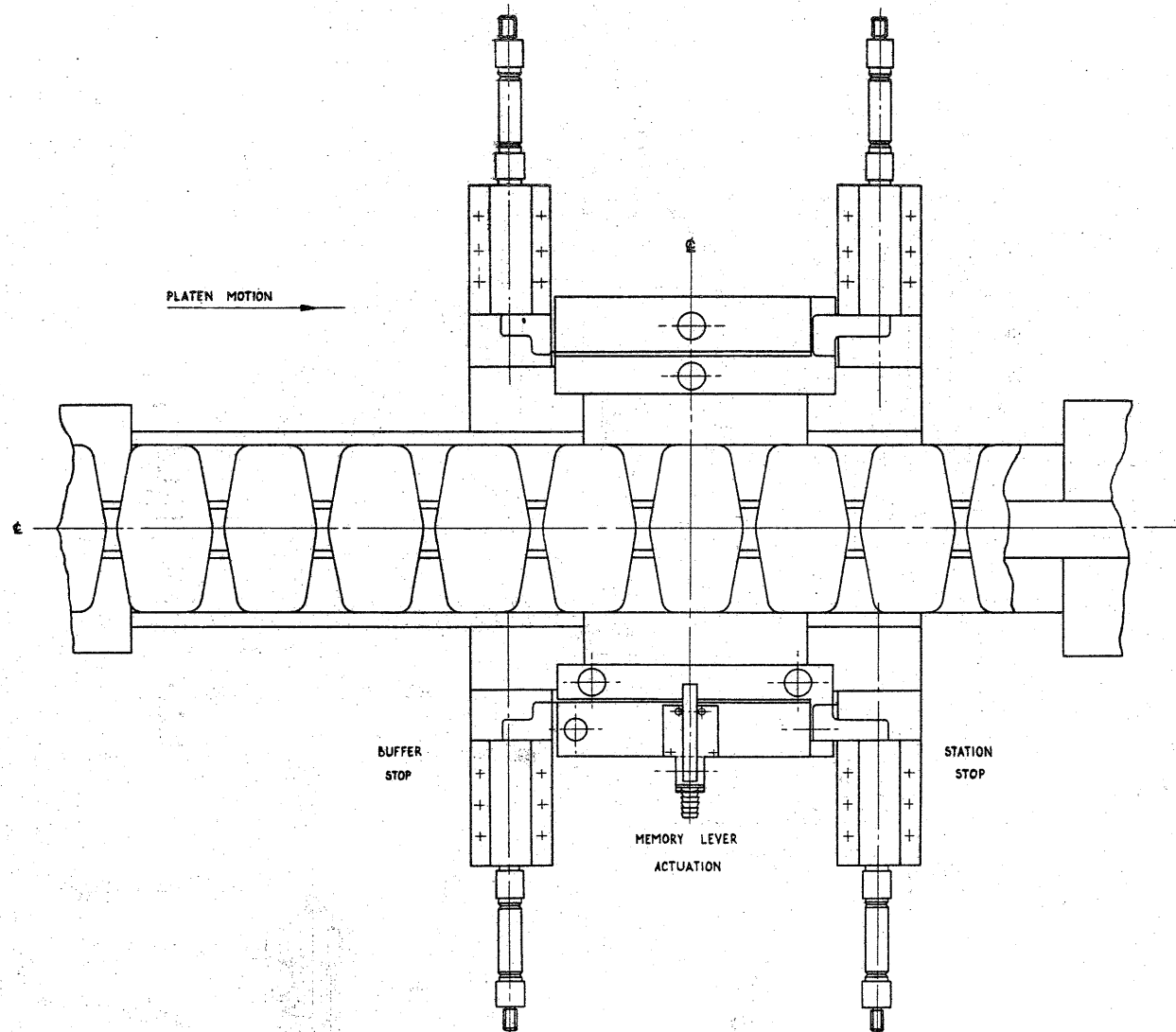
1968/69 GROUP DESIGN PROJECT		
TITLE -	SIDE ELEVATION OF GENERAL ASSEMBLY WITH F/I MECH.	DRG. NO. AP 20

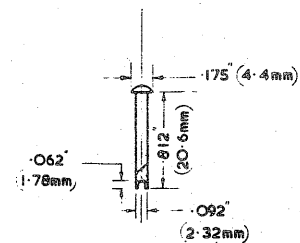
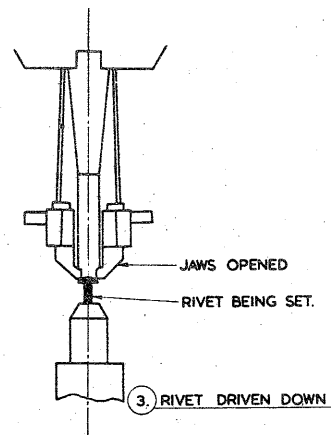
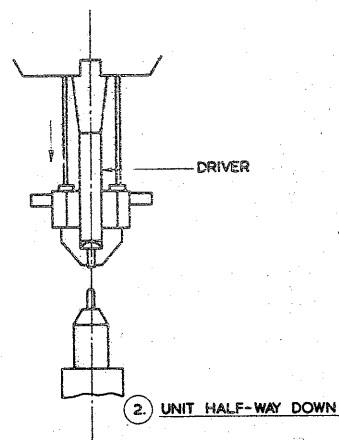
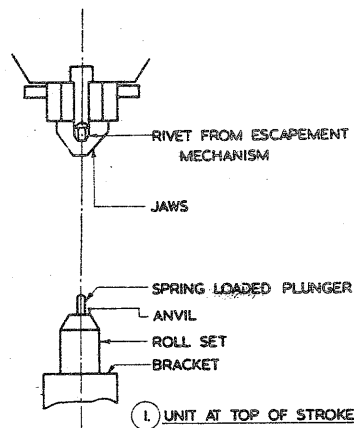




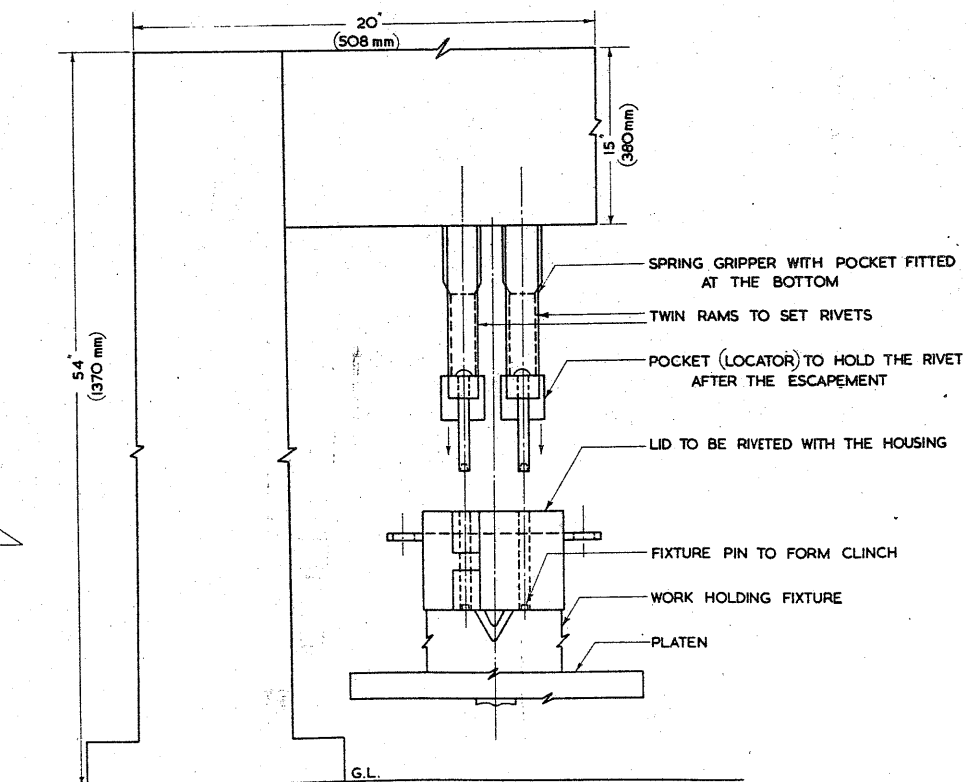
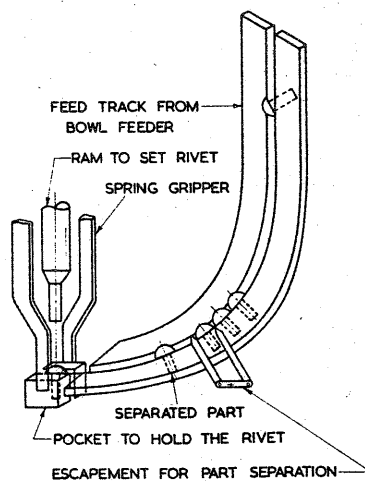
1968/69 GROUP DESIGN PROJECT		
TITLE:	PLAN VIEW OF GENERAL ASSEMBLY OF #1 MECH	DRG. NO. AP 22

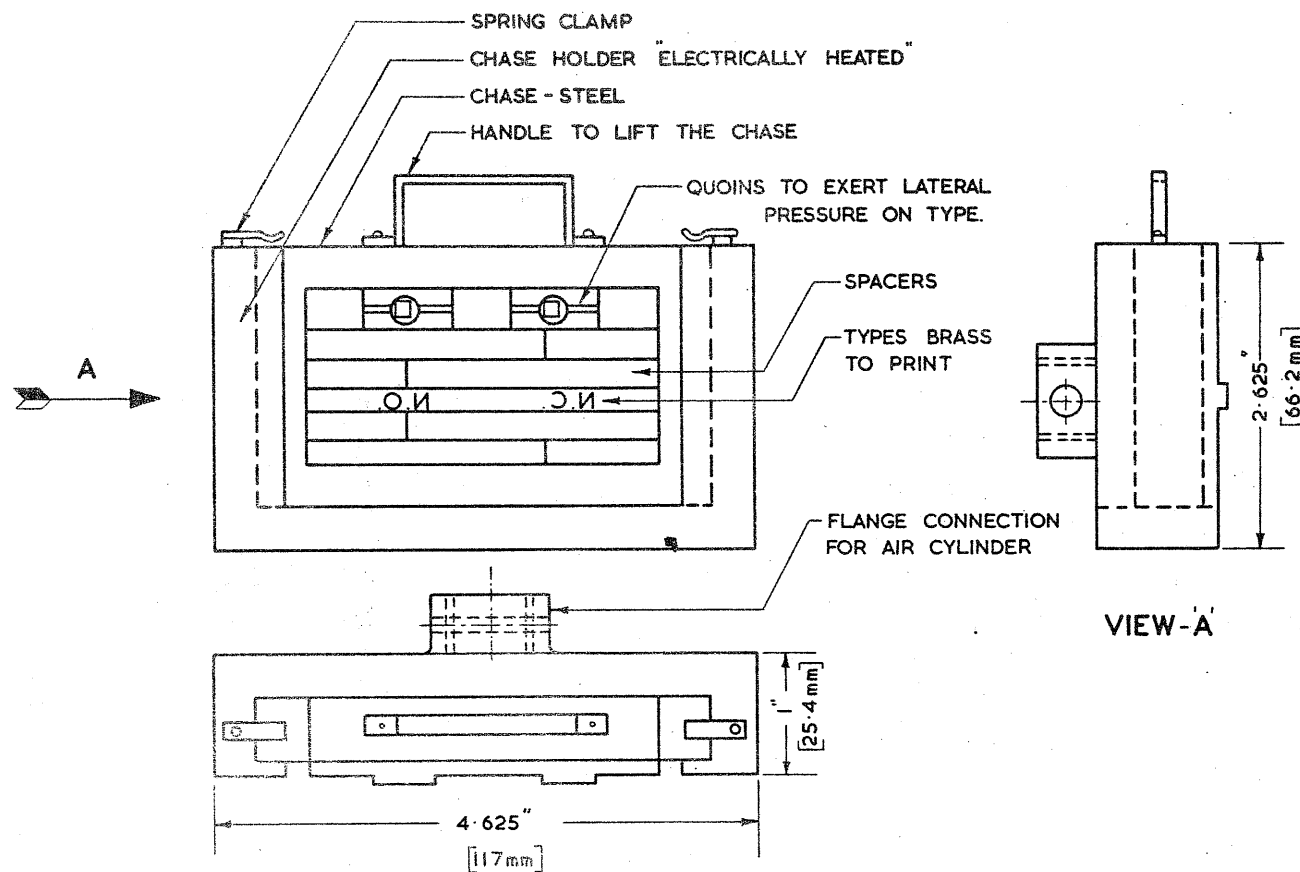
SLAT CHAIN
CONVEYOR



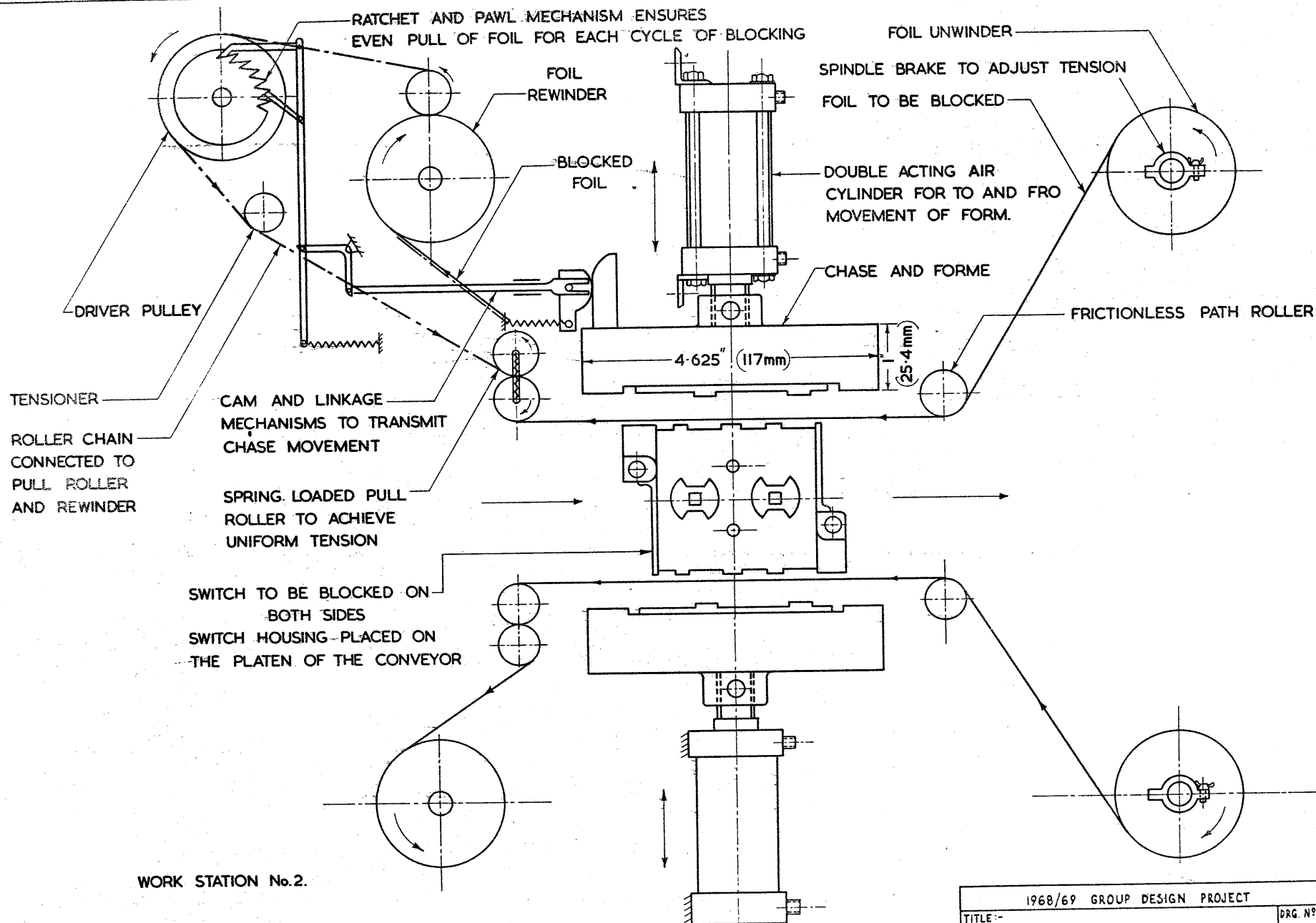


BASIC RIVETING TERMINOLOGY - N.T.S.





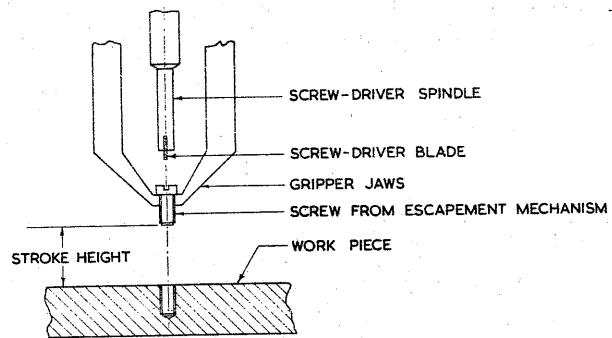
1968/69 GROUP DESIGN PROJECT		
TITLE:-	FORME FOR HOT FOIL BLOCKING MACHINE	DRG. N ^o
		AP 25



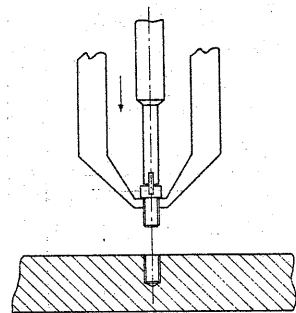
1968/69 GROUP DESIGN PROJECT

TITLE:-
DESIGN OF FOIL BLOCKING HEAD

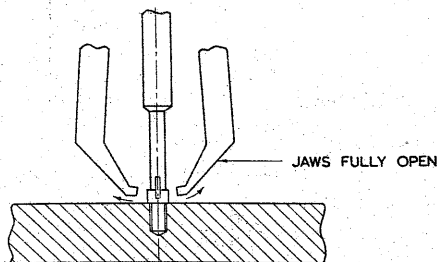
DRG. N^o
AP 26



STEP 1. UNIT AFTER THE PART ESCAPEMENT

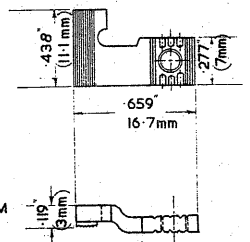


STEP 2. UNIT MID WAY OF ITS STROKE

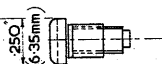
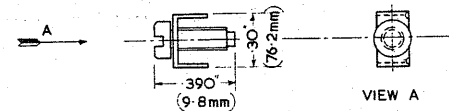


STEP 3. SCREWING OPERATION COMPLETED.

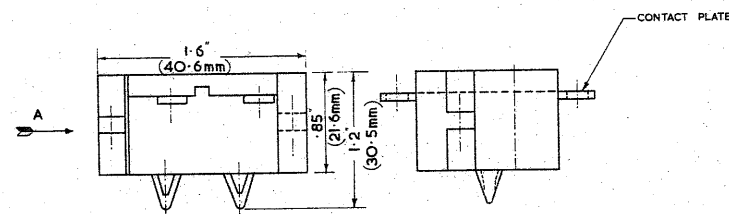
OPERATION SEQUENCE IN SCREW-DRIVER ASSEMBLY~ NOT TO SCALE.



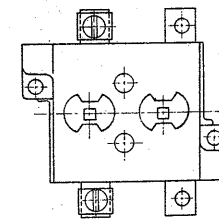
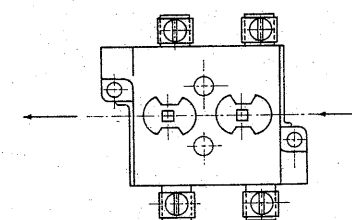
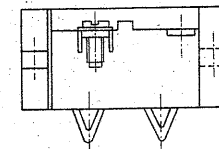
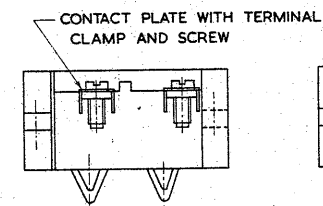
N/O CONTACT PLATE R.H.
3-FULL SIZE



TERMINAL CLAMP AND SCREW
INTEGRAL COMPONENT
3-FULL SIZE



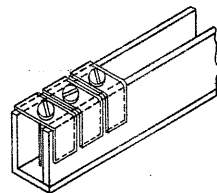
SWITCH ASSEMBLY AFTER WORK STATION No. 7.
TWICE FULL SIZE



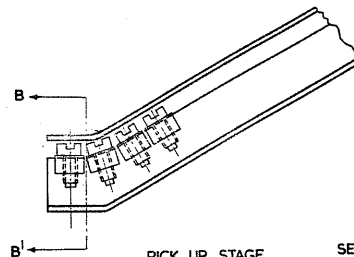
FURTHER TWO SCREWS DRIVEN
ASSEMBLY AFTER STATION No. 9.

TWO SCREWS ONLY DRIVEN
ASSEMBLY AT THE END OF
WORK STATION No. 8.

TWICE FULL SIZE



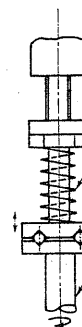
FEED TRACK FOR TERMINAL CLAMP AND SCREW
FROM VIBRATORY BOWL FEEDER



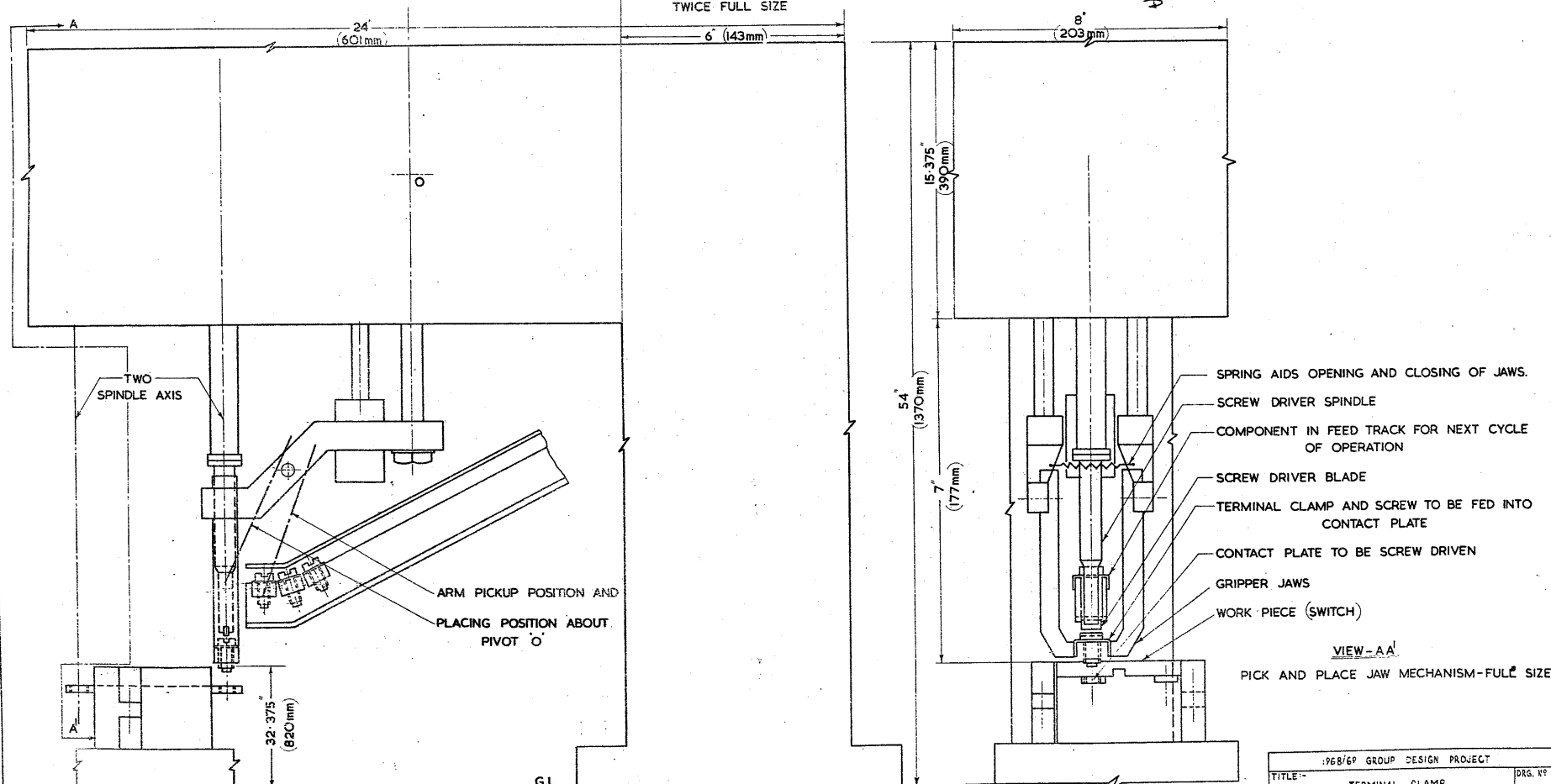
PICK UP STAGE
GRAVITY AND PRESSURE FED COMPONENT
TWICE FULL SIZE

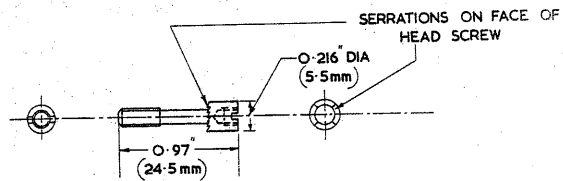


SECTION-BB'

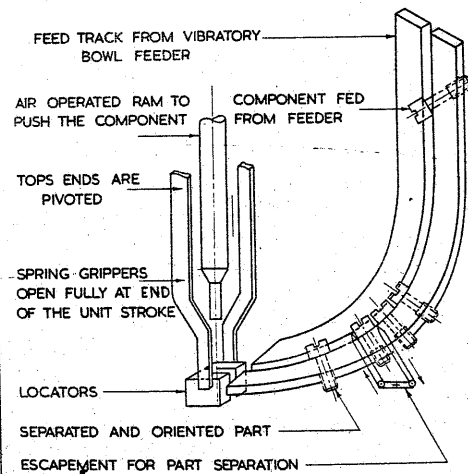


NUTS TO INCREASE SPRING PRESSURE
SPRING TO SUIT RANGE OF TORQUE REQUIRED
BALLS FITTED DETENT
SPINDLE DRIVER
PRE-SET TORQUE MECHANISM-N.T.S.

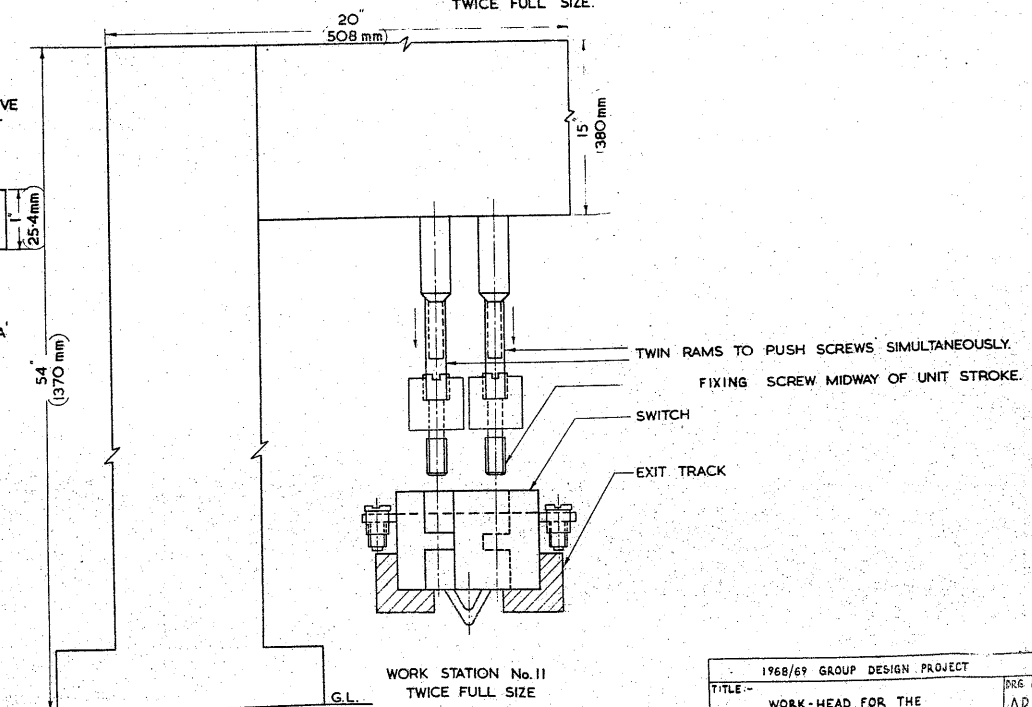
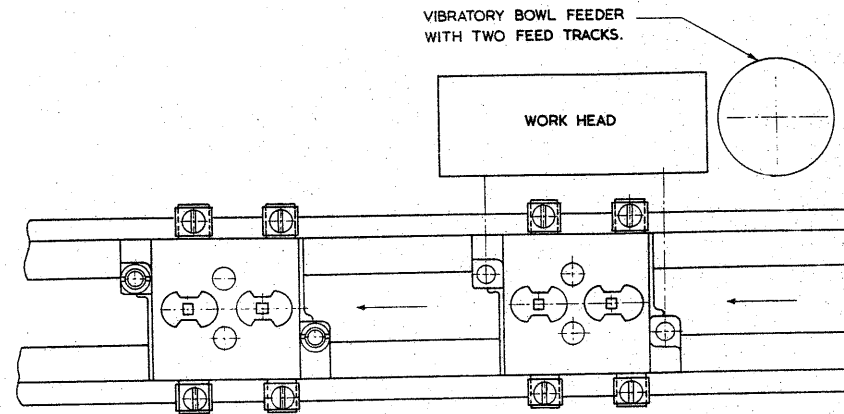
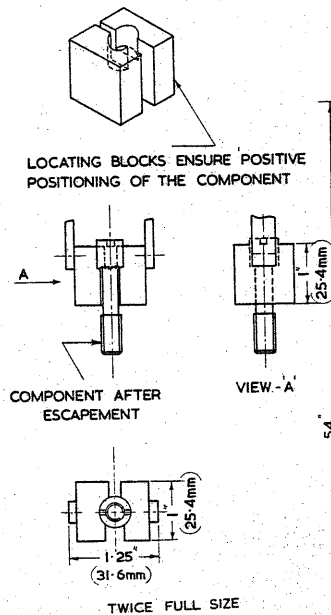


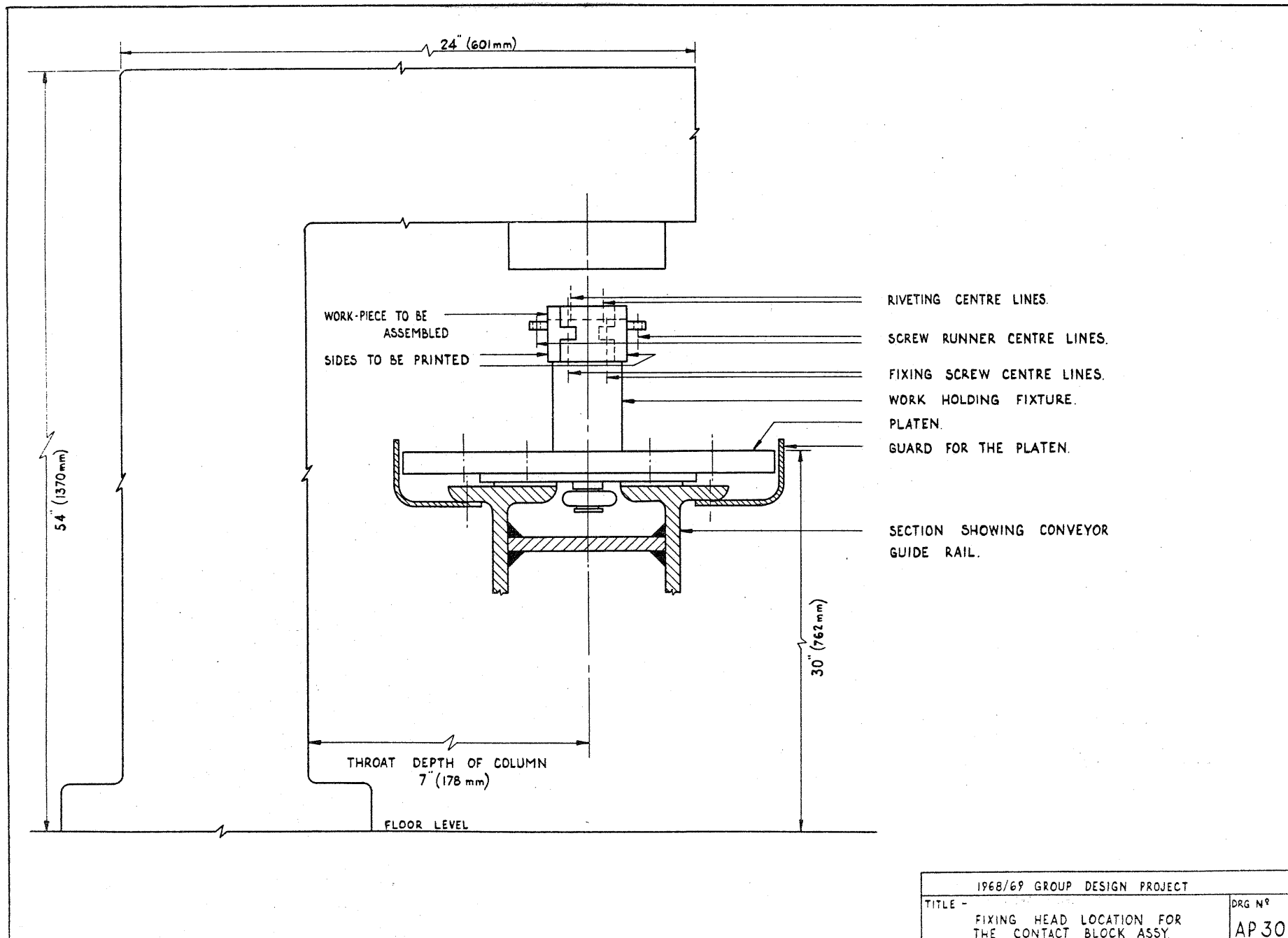


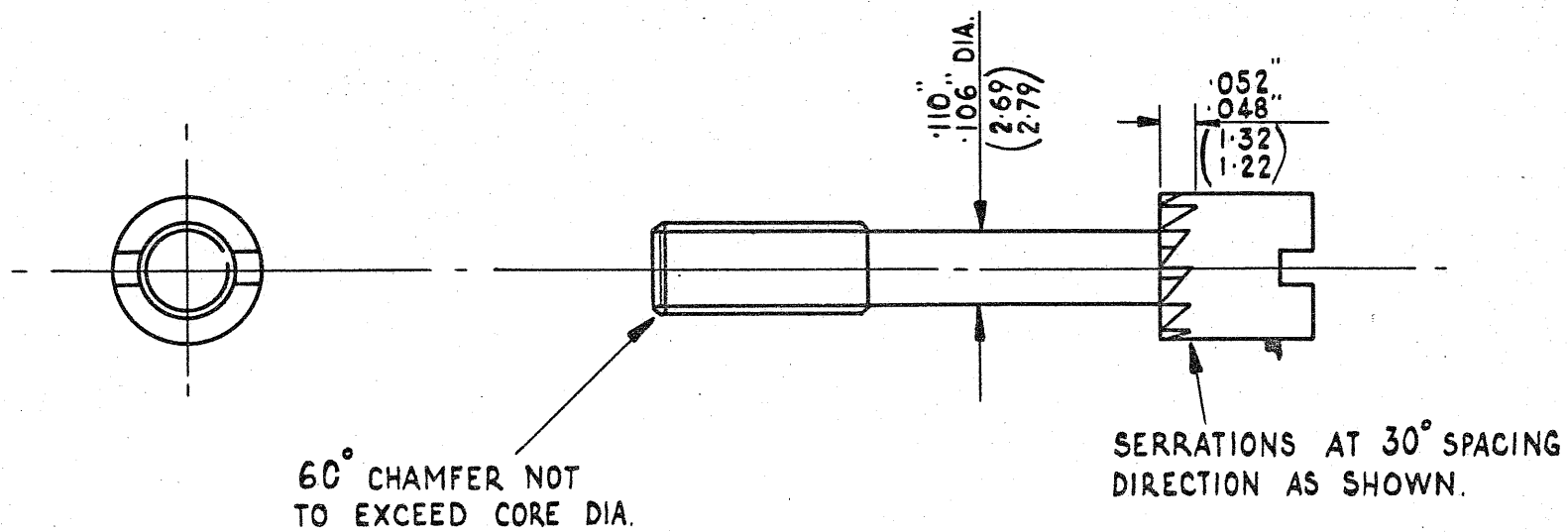
RE-DESIGNED FIXING SCREW
TWICE FULL SIZE



PLACING MECHANISM OF FIXING SCREW
NOT TO SCALE







1968/69 GROUP DESIGN PROJECT		
TITLE :-		DRG. NO.
REDESIGN OF CONTACT BLOCK FIXING SCREW		AP 31